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Watanabe et al.

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(54) **POWER TOOL**

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B25B 23/151 (2006.01)

(52) **U.S. Cl.** **173/20**; 173/48; 173/104; 173/109

(58) **Field of Classification Search** 173/2, 18, 173/20, 48, 104, 109, 117, 217, 162.1, 162.2
See application file for complete search history.

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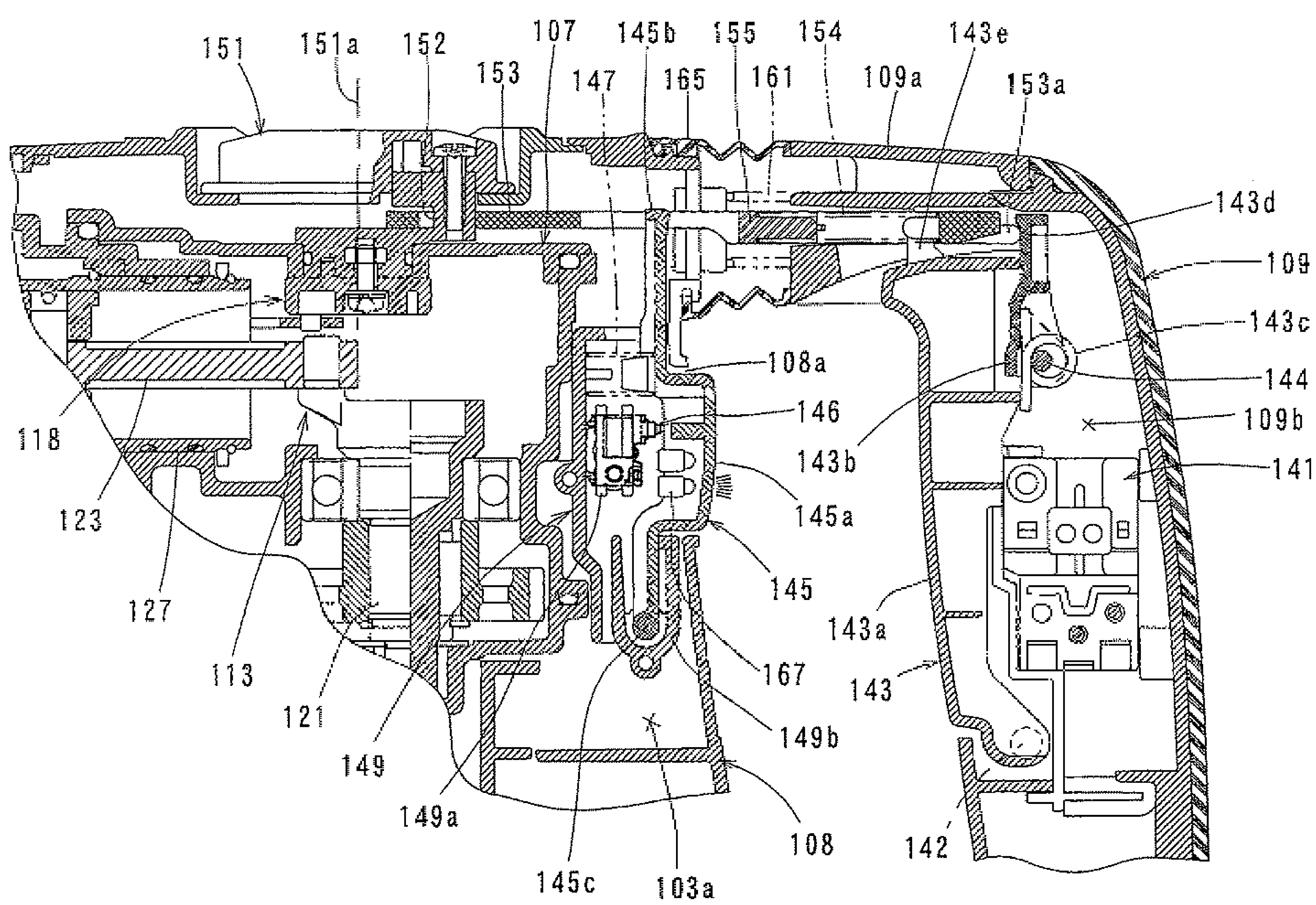
(57) **ABSTRACT**

It is an object of the invention to easily determine a currently-selected operation mode in a power tool which offers several operation modes. A representative electric hammer drill **101** embodying a power tool according to the invention has a controller **171** for at least controlling a driving motor **111**. The controller **171** includes a switch detecting circuit **173** that detects the on or off state of each of first and second switches **141**, **146** when power is on, a computing/driving section **174** that determines a current operation mode based on results of detection of the switch detecting circuit **173**, and a motor control section **176** and a drive circuit **177** that output a drive control signal to the driving motor **111** when the switch in the off state is turned on after the computing/driving section **174** determines the operation mode.

11 Claims, 11 Drawing Sheets



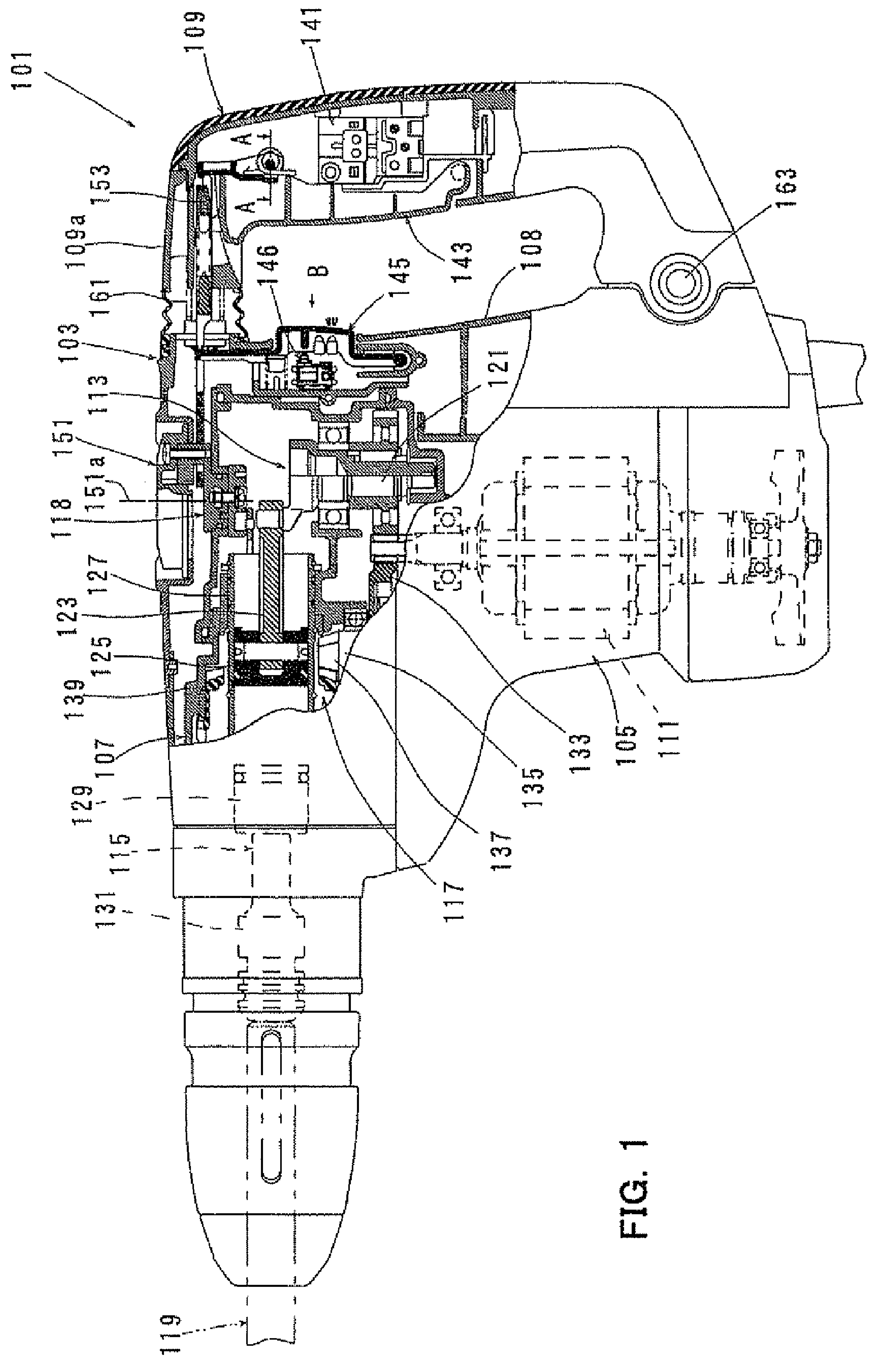

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FIG. 1

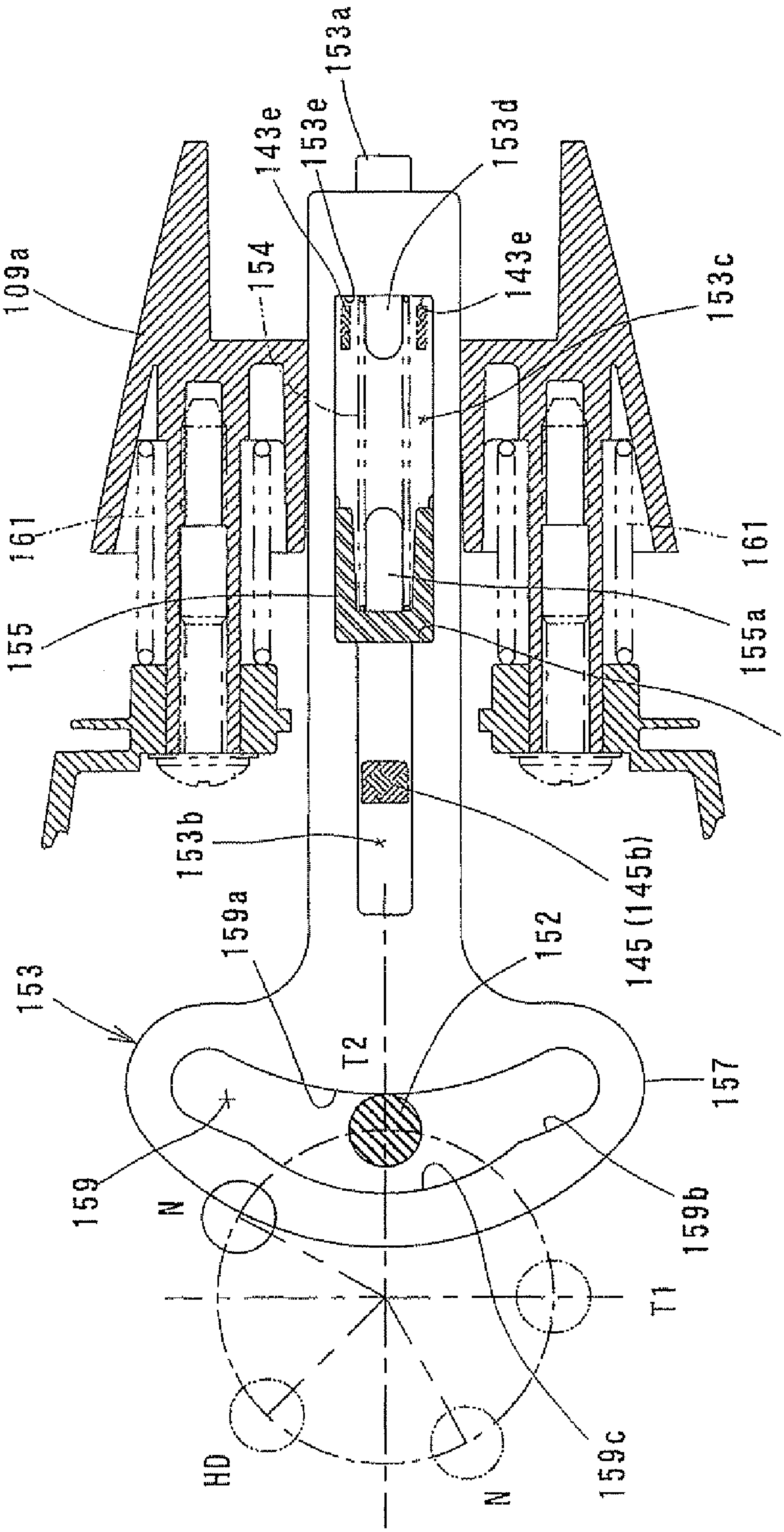
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FIG. 2

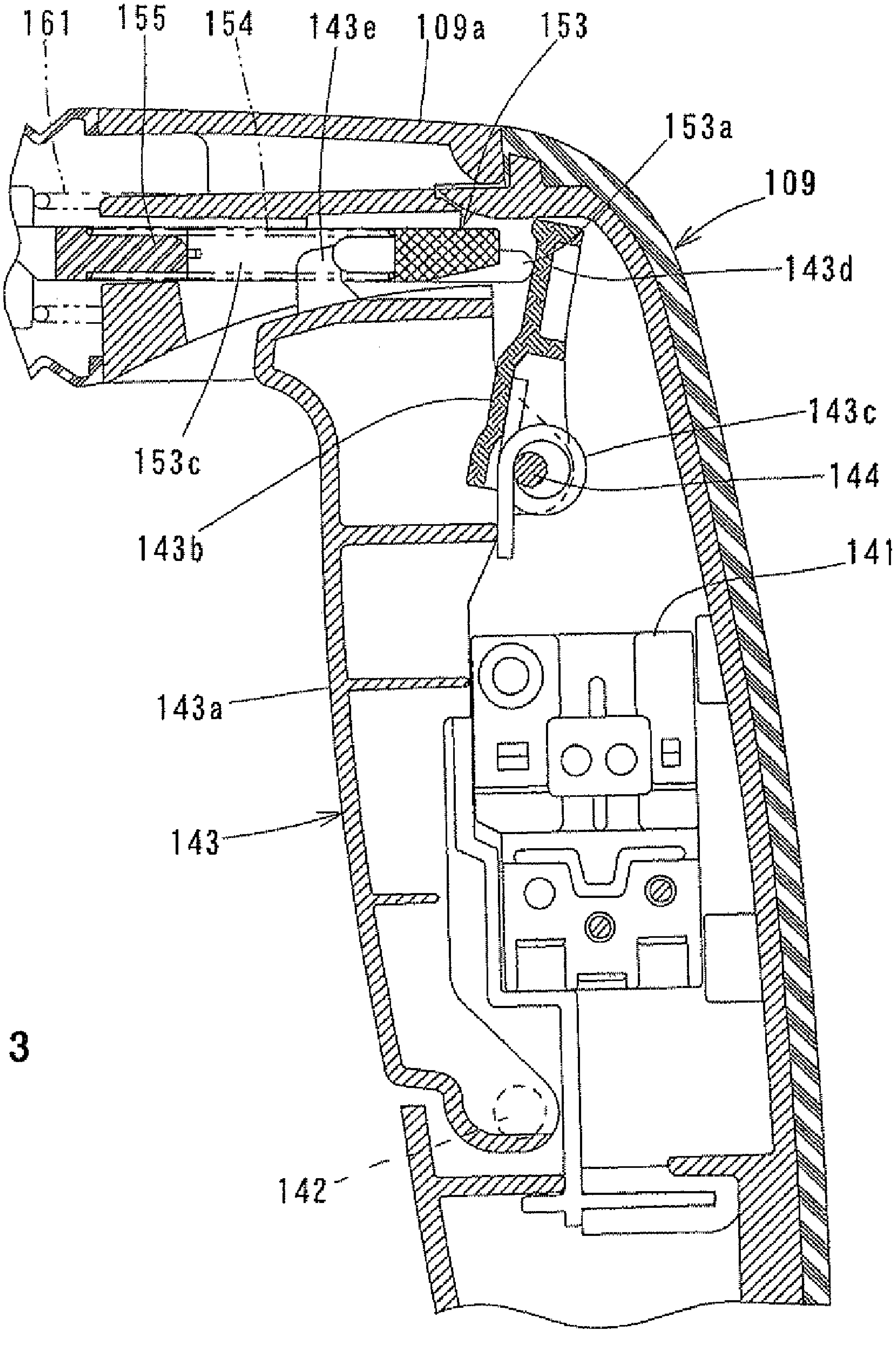
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FIG. 3

FIG. 4

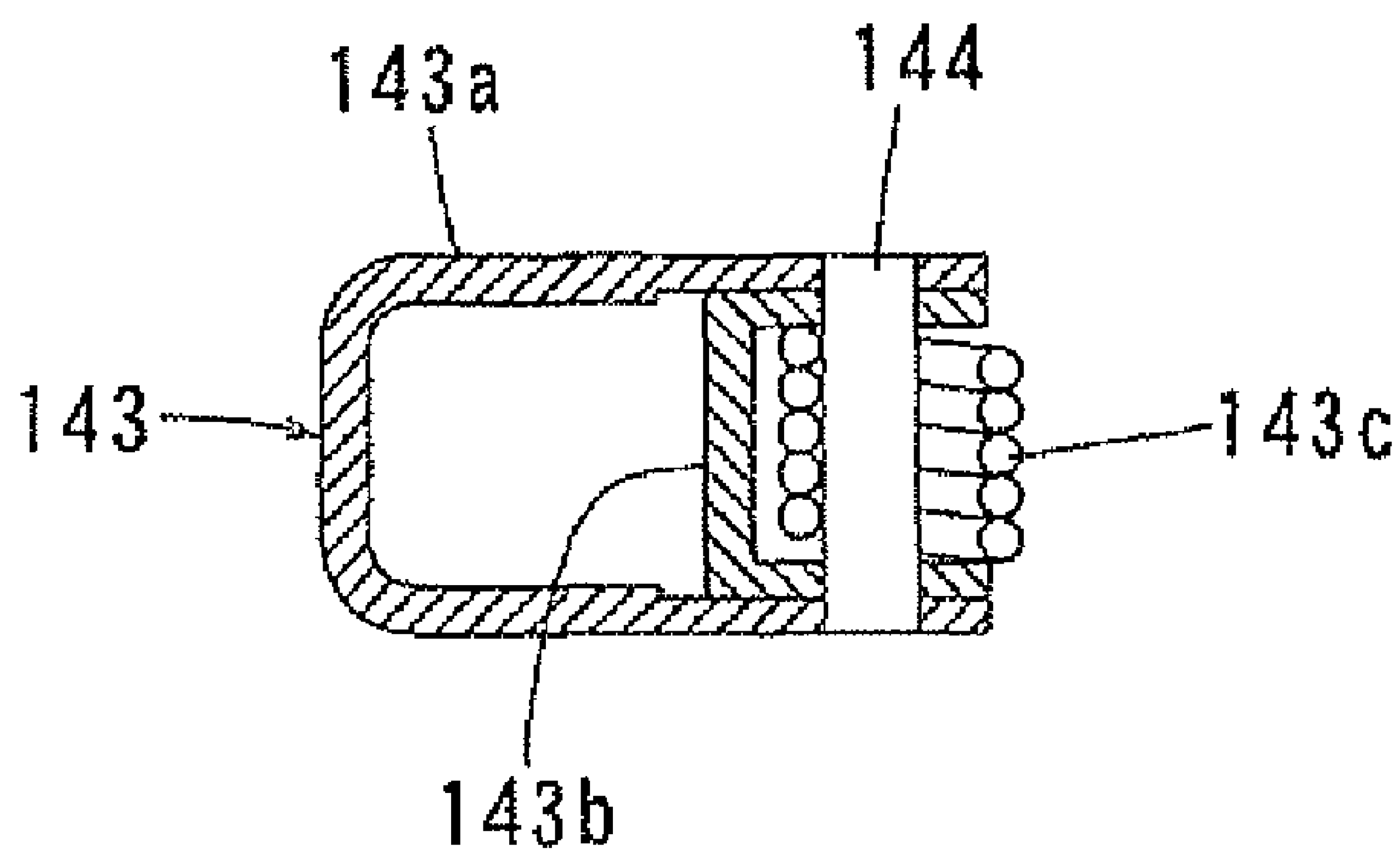
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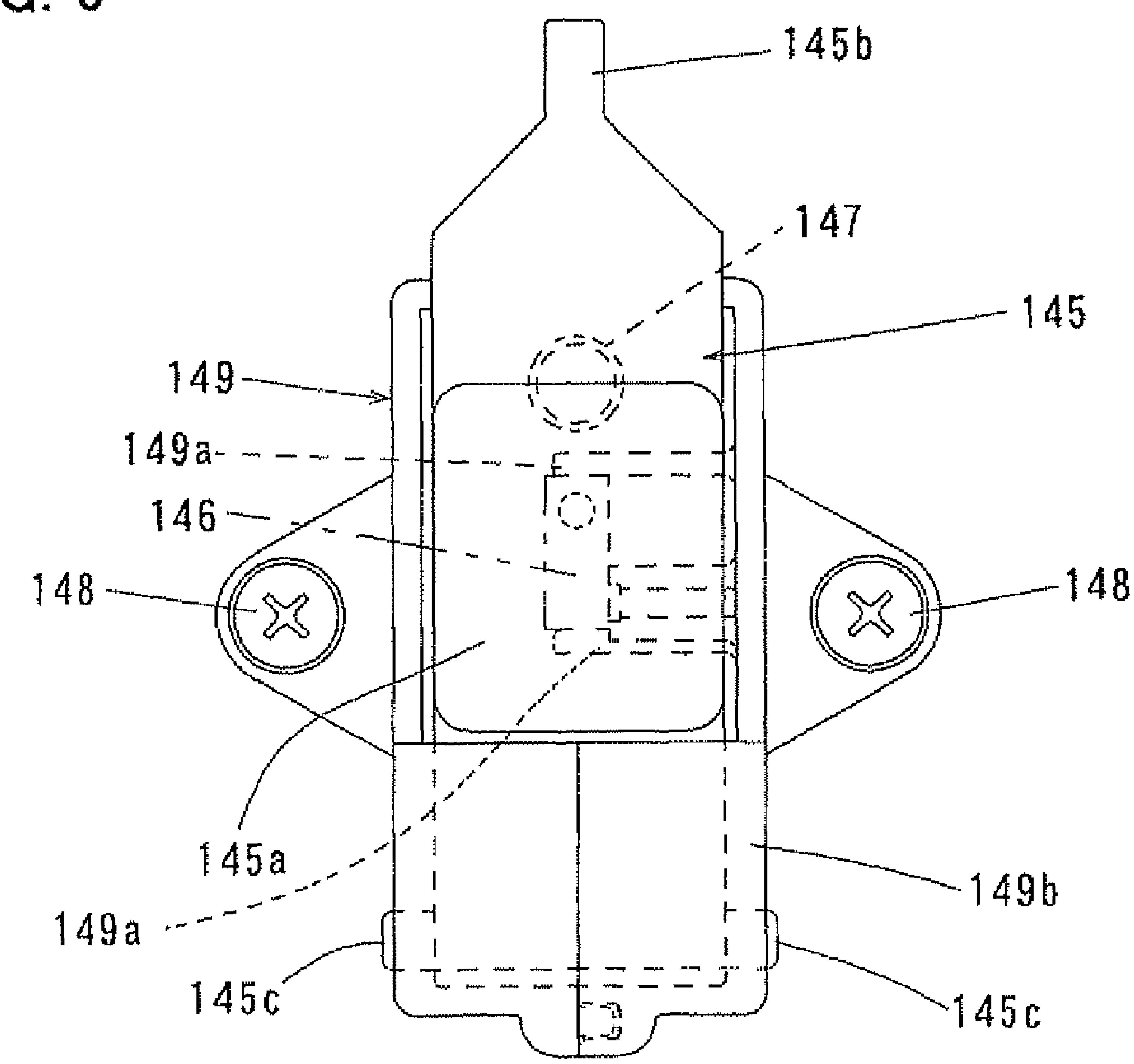
FIG. 5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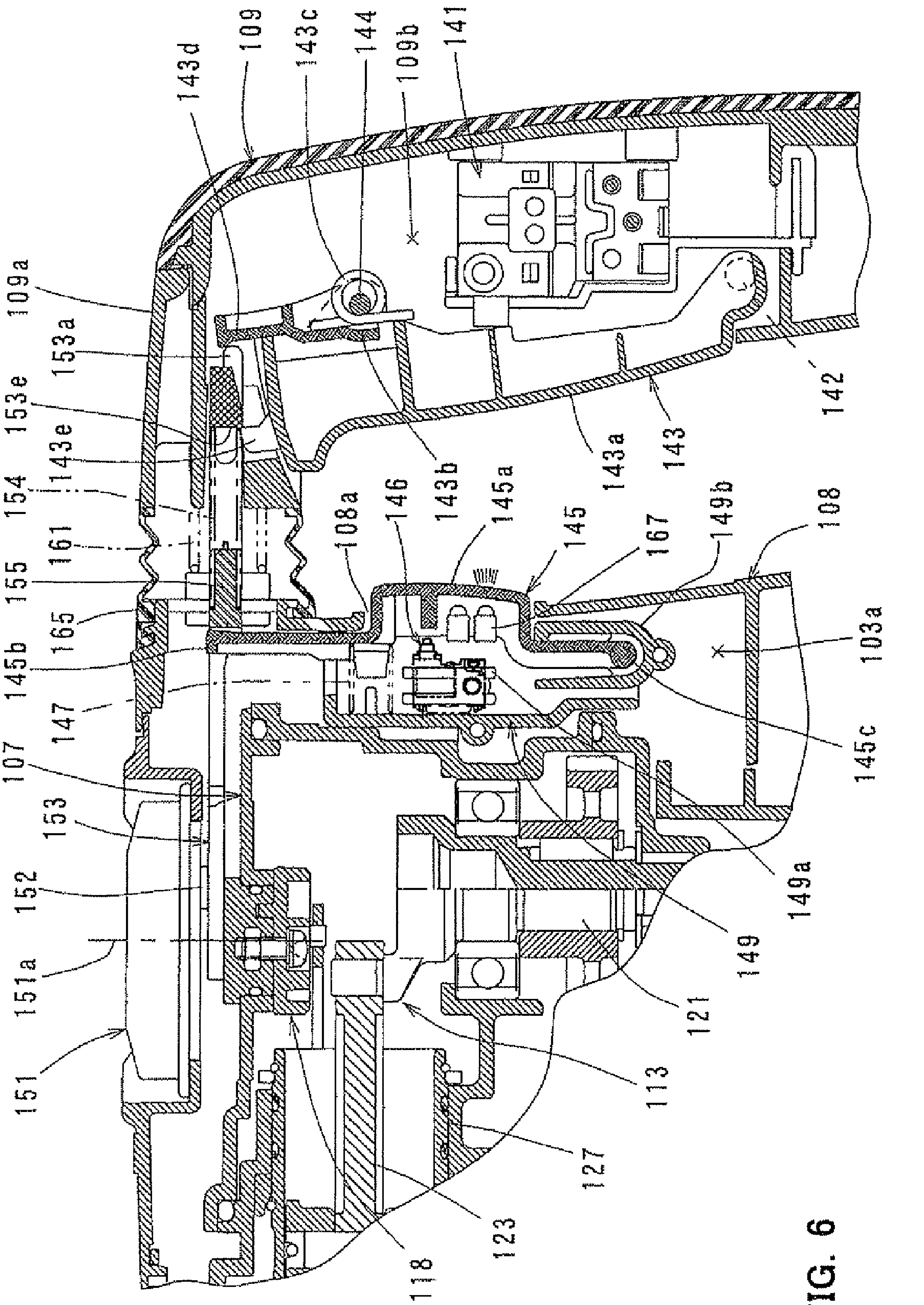
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151a
151
143b
145a
146
108a
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167
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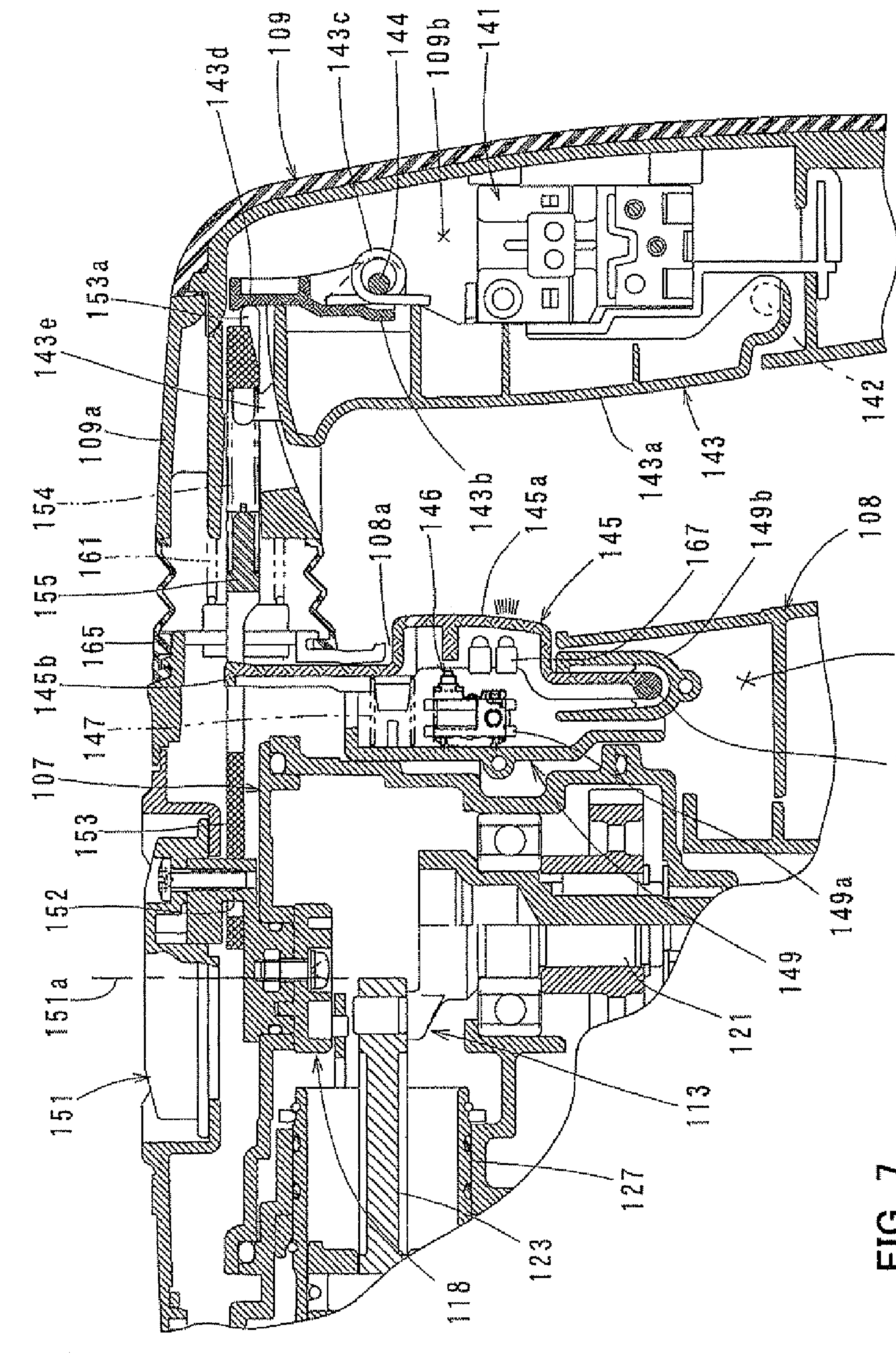
142
103a
145c
149a
149
121
113
127
123
118

FIG. 6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143a
143
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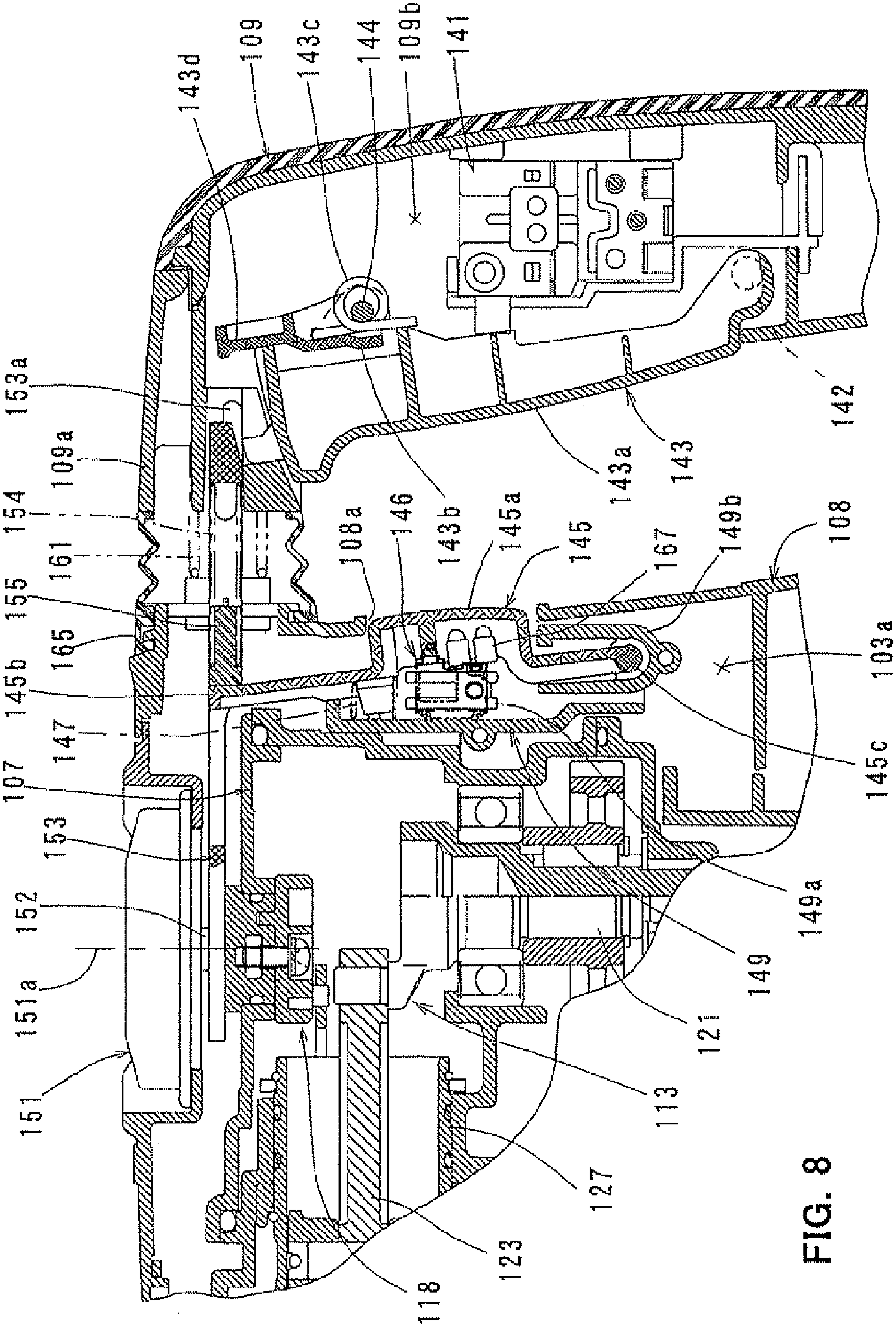
149a
149
121
113
127
123
118

FIG. 7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143b
143a
143
142
108a
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103a
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149a
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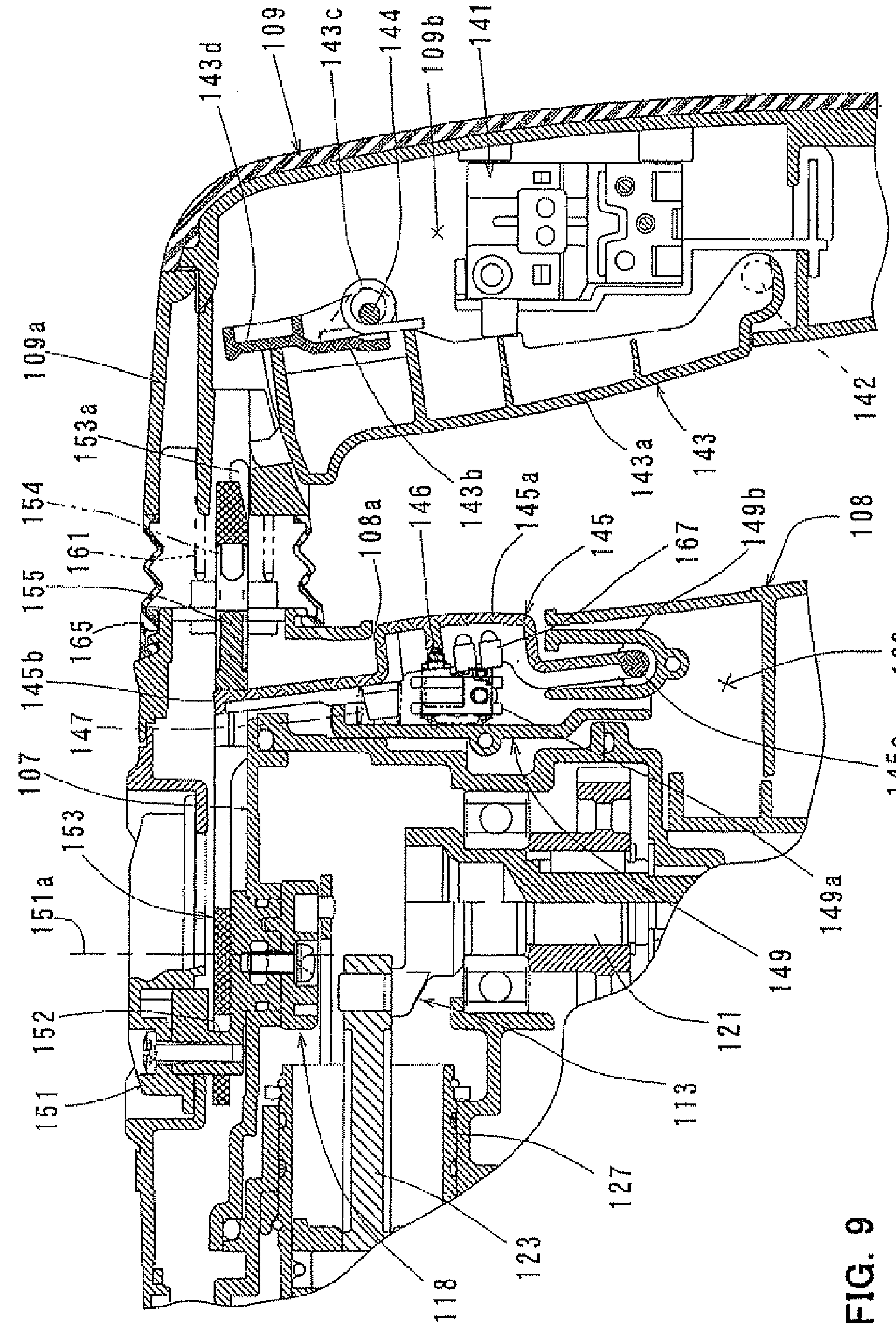
121
113
127
123
118

FIG. 8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146
108a
145a
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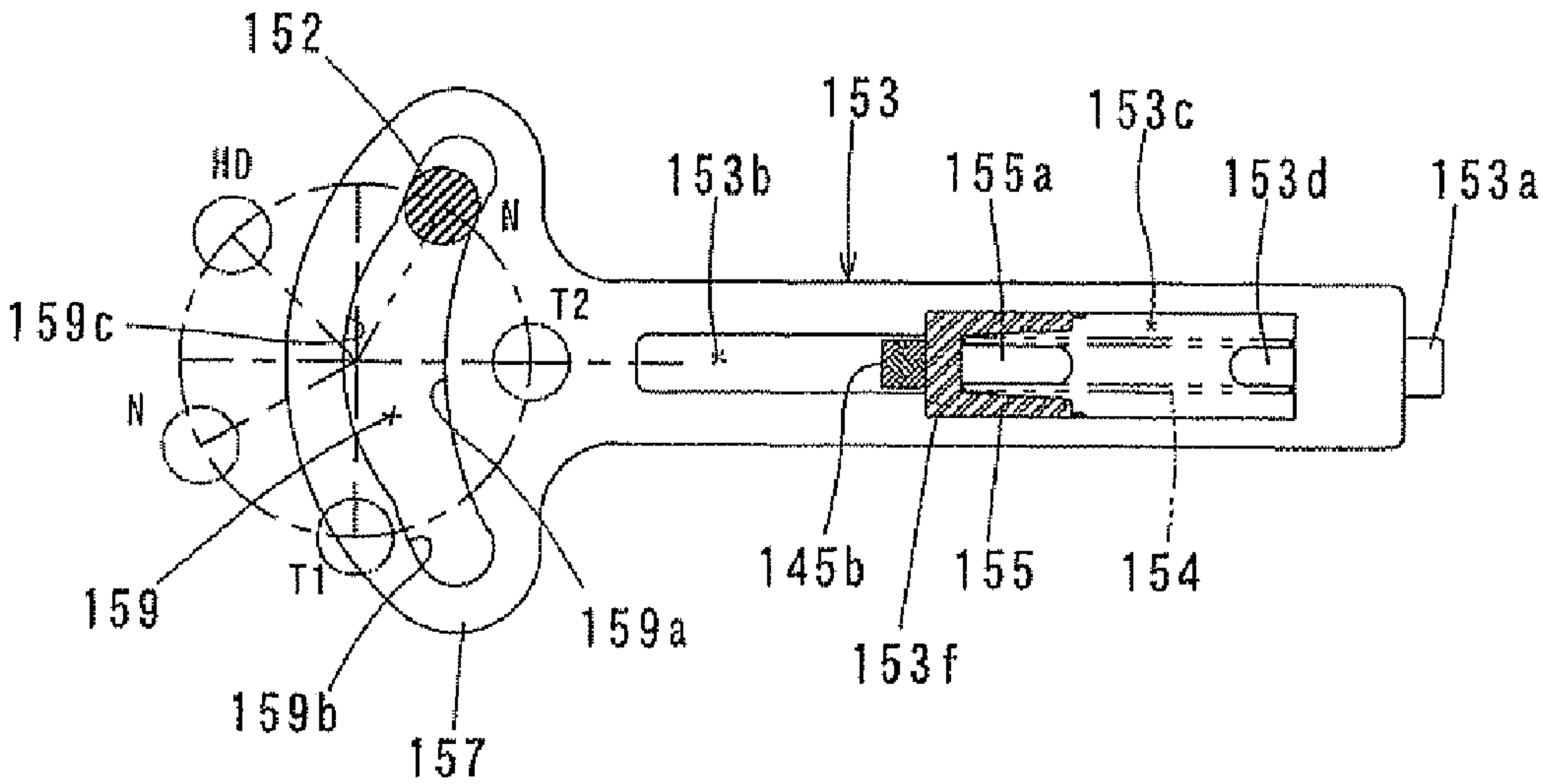
FIG. 9

FIG. 10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153f
159b
157

FIG. 11

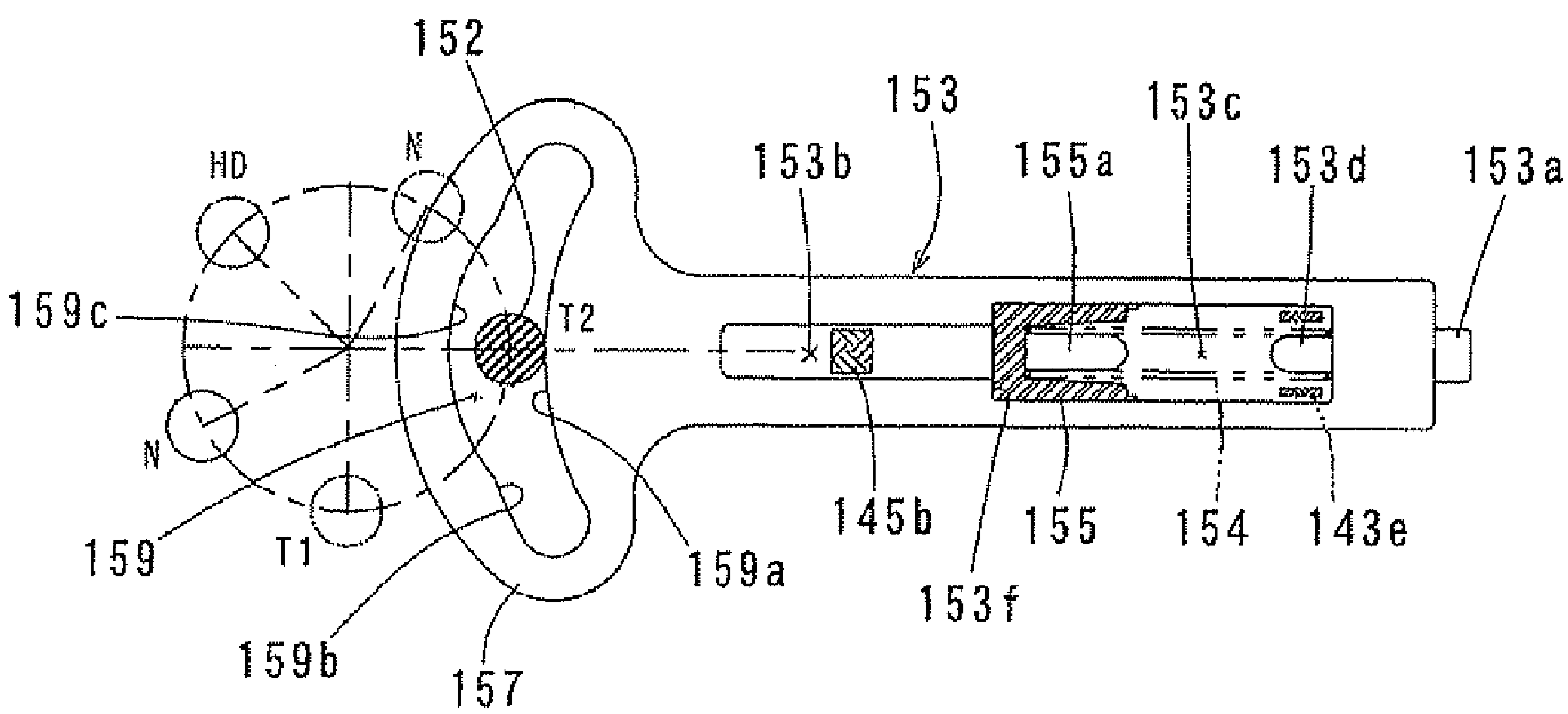
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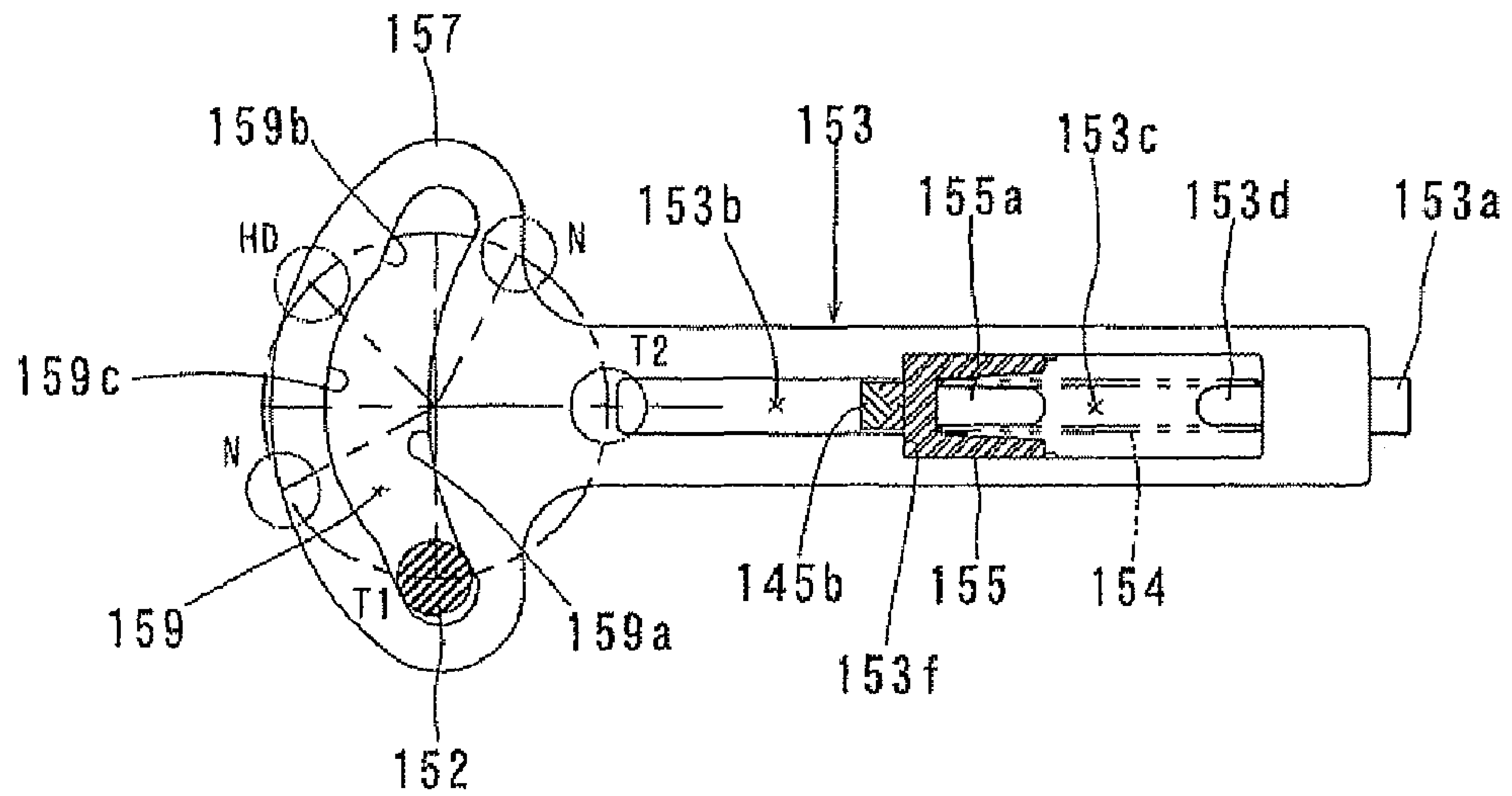
FIG. 12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153f
152

FIG. 13

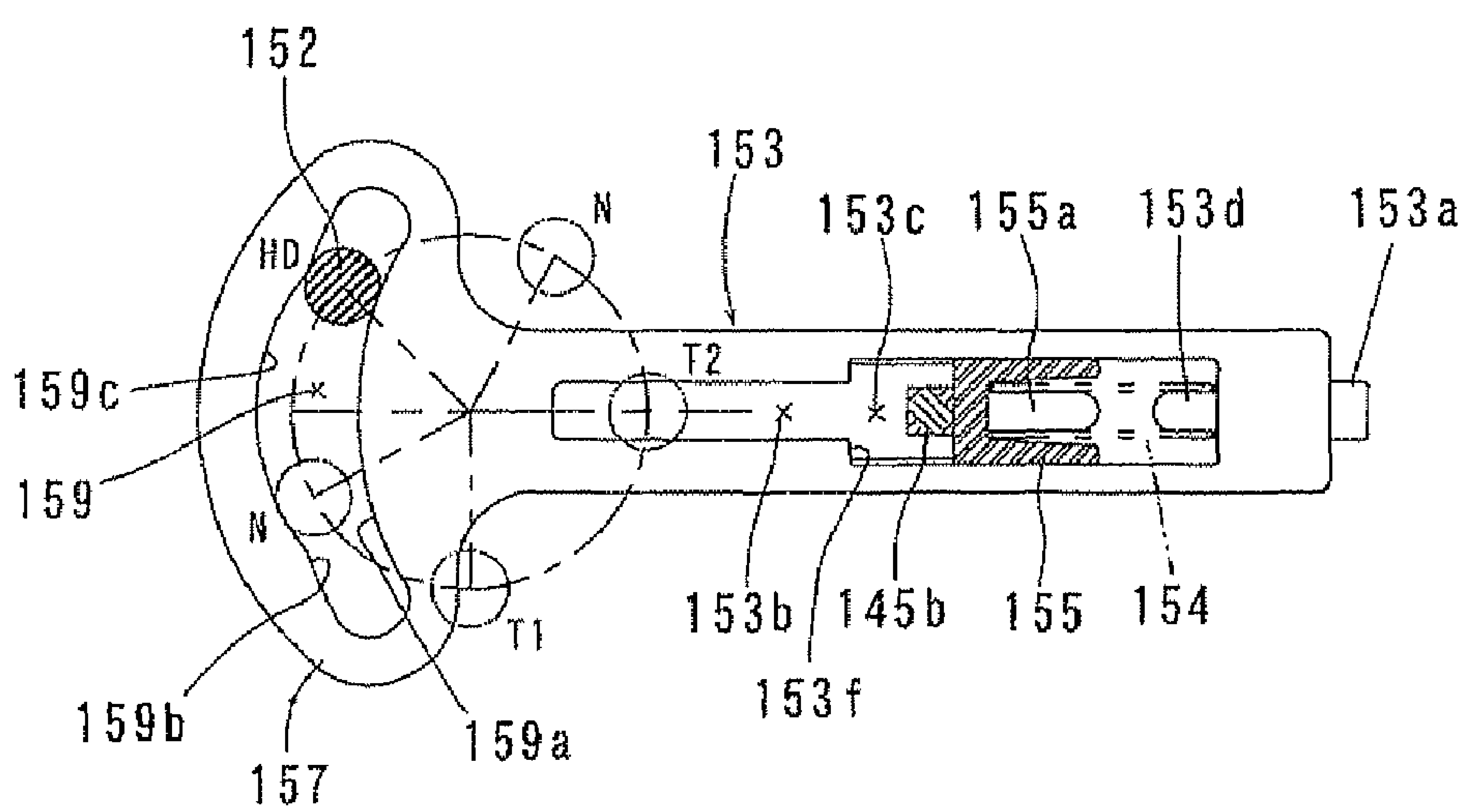
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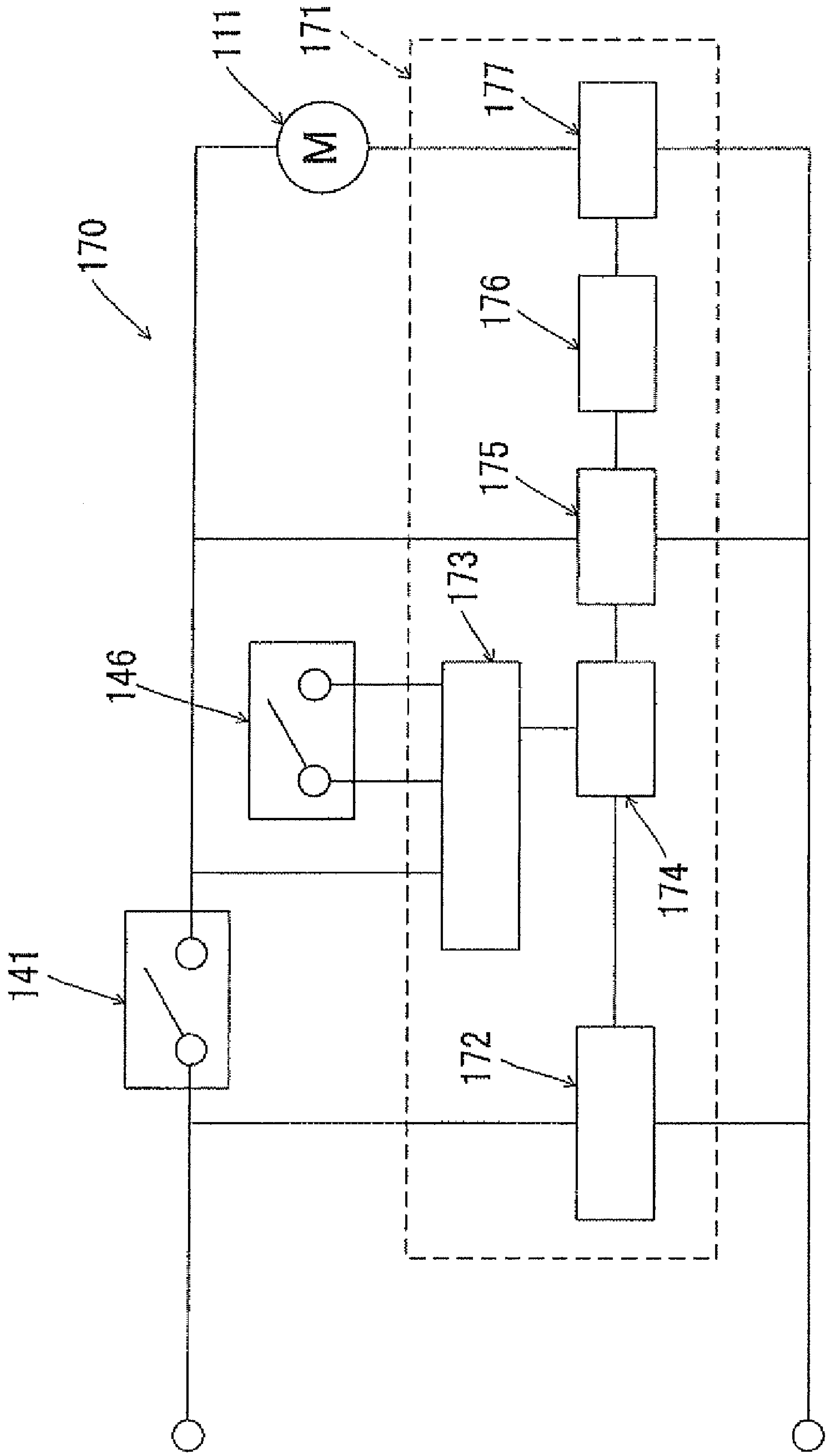
FIG. 14



POWER TOOL

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a power tool which is capable of performing an operation on a workpiece by a tool bit.

2. Description of the Related Art

Japanese laid-open patent publication No. 2006-957 discloses an electric impact tool in which a tool bit is driven by a motor and performs a striking movement. Further, an operation mode switching mechanism is provided which can switch between first operation mode in which a first switch is allowed to be turned on by a user and a second switch is locked in an on position, and second operation mode in which the first switch is locked in an on position and the second switch is allowed to be turned on by the user.

According to the known art, when one of the switches which is not locked is turned on in each drive mode, the tool bit can be driven in the specific drive mode. It is desired in mode setting of a power tool of this type to easily determine the operation mode by detecting the on/off state of the first and second switches is further required.

SUMMARY OF THE INVENTION

It is, accordingly, an object of the invention to easily determine a currently-selected operation mode in a power tool which offers several operation modes.

Above described object can be achieved by the claimed invention. A representative power tool according to the invention offers several operation modes and includes at least a motor, a tool body, a tool bit mounting part, a handle, a first switch, a second switch and a control device. User can perform a predetermined operation by the power tool placed in the appropriate operation mode.

The tool body houses the motor. The tool bit mounting part is provided on the tool body and an elongate tool bit to be driven by the motor is coupled to the tool bit mounting part. The tool bit may be a component of the power tool or the tool body, or it may be a component separate from the power tool or the tool body. The handle is designed to be held by a user and disposed on a side of the tool body opposite from the tool bit mounting part in an axial direction of the tool bit. The first switch and the second switch can be placed in an on state or an off state. The control device serves to control the motor.

The control device includes at least a switch detecting section, an operation mode determining section and a drive control section. The switch detecting section detects the on or off state of each of the first and second switches when power is on. The state in which "power is on" widely includes the on state of the power, and such a state is typically created immediately after the power is turned on. The operation mode determining section determines a current operation mode based on results of detection of the switch detecting section. Typically, when it is detected that the first switch is on, it is determined that one operation mode is currently selected, while, when it is detected that the second switch is on, it is determined that another operation mode is currently selected. With such a construction, it can be readily determined which one of the operation modes is currently selected.

Particularly, according to this invention, by provision of the switch detecting circuit for directly detecting the on/off state of the first and second switches, an additional switch to be provided for this purpose can be rationally dispensed with. The drive control section serves to output a drive control signal to the motor when the switch in the off state is turned on after the operation mode determining section determines the operation mode. Therefore, if it is determined that the first operation mode is currently selected, the motor is driven when it is detected that the switch to be turned from the off state to the on state in the first operation mode is in the on state, while, if it is determined that the second operation mode is currently selected, the motor is driven when it is detected that the switch to be turned from the off state to the on state in the second operation mode is in the on state.

According to one aspect of the invention, the power tool preferably includes an operation mode switching member which can switch between the operation modes by manual operation of a user. The operation modes include a first hammer mode and a second hammer mode for hammering operation in which the tool bit is caused to perform linear striking movement. In the first hammer mode, by manual operation of the operation mode switching member, the second switch is held in the on state and the first switch is allowed to be turned to the on or off state. In the second hammer mode, by manual operation of the operation mode switching member, the first switch is held in the on state and the second switch is allowed to be turned to the on or off state.

With such a construction, it can be readily determined whether either the first hammer mode or the second hammer mode is currently selected among the several operation modes. If the first hammer mode is selected by manual operation of the operation mode switching member, the motor is driven when it is detected that the first switch is turned from the off state to the on state, while, if the second hammer mode is selected by manual operation of the operation mode switching member, the motor is driven when it is detected that the second switch is turned from the off state to the on state.

According to one aspect of the invention, the power tool includes an operation mode switching member which can switch between the operation modes by manual operation of a user. The operation modes include a hammer drill mode for hammer drill operation in which the tool bit is caused to perform linear striking movement and rotation in its circumferential direction. In the hammer drill mode, by manual operation of the operation mode switching member, the second switch is held in the on state and the first switch is allowed to be turned to the on or off state.

With such a construction, it can be readily determined whether the hammer drill mode is currently selected among the several operation modes. If the hammer drill mode is selected by manual operation of the operation mode switching member, the motor is driven when it is detected that the first switch is turned from the off state to the on state.

Further, according to one aspect of the invention, the operation modes preferably include a mode in which the tool bit is caused to rotate and a mode in which the tool bit is not caused to rotate, and a process of switching between these modes includes a switching process in which both of the first and second switches are placed in the off state. In this case, all or part of the process of switching between the modes can be a switching process in which both of the first and second switches are placed in the off state. With such a construction, the power tool is provided such that both of the first and second switches are placed in the off state in the process of switching between a mode in which the tool bit is caused to rotate and a mode in which the tool bit is not caused to rotate.

Further, according to one aspect of the invention, the power tool includes a first operating member which is normally biased toward an off position by a biasing means and which is depressed to an on position against a biasing force of the biasing means in order to turn on the first switch. Further, the handle has a first housing space in which the first operating member can be housed and the first operating member is housed in the first housing space in the state in which the first switch is held in the on state by manual operation of the operation mode switching member in the second hammer mode.

With such a construction, the biasing force of the biasing means can be prevented from acting upon the user via the first operating member when the first switch is held in the on state by manual operation of the operation mode switching member in the second hammer mode, so that this is effective in smoothly performing the operation.

Further, according to one aspect of the invention, the power tool preferably includes a second operating member which is repeatedly pressed with user's finger in order to turn the second switch on and off. Further, the tool body has a second housing space in which the second operating member can be housed and the second operating member is housed in the second housing space in the state in which the second switch is held in the on state by manual operation of the operation mode switching member in the first hammer mode or the hammer drill mode.

With such a construction, by visually checking whether the second operating member is housed or not, the user can readily identify the currently selected operation mode.

Further, according to one aspect of the invention, the second switch preferably comprises an electronic switch which energizes and de-energizes the motor by electric signals generated upon pressing operation of the second operating member. Specifically, this electronic switch is designed as a switch which does not have a mechanical contact for passing and interrupting motor current. With such a construction, the second switch can be reduced in size and the second operating member can be pressed with a light touch so that ease of operation is enhanced.

Further, according to one aspect of the invention, the power tool preferably includes an indicating section that indicates by illumination which one of the operation modes is currently selected. The manner of indication by the indicating section may include the manner of flashing or illuminating in a single color or multiple colors. With such a construction, the user can readily identify the currently selected operation mode via the indicating section.

Further, according to one aspect of the invention, the indicating section preferably indicates the current operation mode based on the on-off state of the second switch. The indicating section is typically designed, for example, to indicate that the second switch is in the off state, or to indicate that the second switch is in the on state, or to indicate that the second switch has been switched between the on state and the off state. With such a construction, the user can readily identify the currently selected operation mode via the indicating section based on the on-off state of the second switch.

Further, according to one aspect of the invention, the power tool preferably includes a vibration-proofing cushioning material which is disposed between the tool body and the handle and connects the tool body and the handle such that the tool body and the handle can move with respect to each other in the axial direction of the tool bit. With such a construction, the vibration-proofing cushioning material can prevent or reduce transmission of vibration from the tool body to the handle when a predetermined operation is performed by driving the tool bit. As the "vibration-proofing cushioning material" in this invention, typically, a spring or a rubber is used.

Further, according to one aspect of the invention, the power tool preferably includes a first operating member and a second operating member, and the first operating member is disposed on the tool bit mounting part side of the handle and the second operating member is disposed in a region of the tool body which faces the first operating member. The first operating member is normally biased toward an off position by a biasing means and the first operating member is depressed to an on position against a biasing force of the biasing means in order to turn on the first switch. The second operating member is repeatedly pressed with user's finger in order to turn the second switch on and off. By such arrangement of the first operating member and the second operating member which are opposed to each other, the first operating member and the second operating member can be operated by fingers of the user's hand holding the handle. Therefore, operability of the operating members for the user can be improved.

According to this invention, in a power tool which offers several operation modes, a currently-selected operation mode can be easily determined. Other objects, features and advantages of the present invention will be readily understood after reading the following detailed description together with the accompanying drawings and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cutaway side view showing an entire electric hammer drill according to an embodiment of the invention.

FIG. **2** is a plan view for illustrating the construction of a switch-actuating slide plate and the arrangement of the slide plate and vibration absorbing coil springs.

FIG. **3** is a sectional view showing the operating status of a handgrip.

FIG. **4** is a sectional view taken along line A-A in FIG. **1**.

FIG. **5** is a view showing a second operating member and a receiving member as viewed from a direction of arrow B in FIG. **1**.

FIG. **6** is an enlarged sectional view showing operation of the slide plate which is operated by an operation mode switching dial, and first and second operating members which are operated by the slide plate, in neutral mode.

FIG. **7** is an enlarged sectional view showing operation of the slide plate which is operated by the operation mode switching dial, and the first and second operating members which are operated by the slide plate, in second hammer mode.

FIG. **8** is an enlarged sectional view showing operation of the slide plate which is operated by the operation mode switching dial, and the first and second operating members which are operated by the slide plate, in first hammer mode.

FIG. **9** is an enlarged sectional view showing operation of the slide plate which is operated by the operation mode switching dial, and the first and second operating members which are operated by the slide plate, in hammer drill mode.

FIG. **10** is a view showing movement of the operation mode switching dial and the slide plate in neutral mode.

FIG. **11** is a view showing movement of the operation mode switching dial and the slide plate in second hammer mode.

FIG. **12** is a view showing movement of the operation mode switching dial and the slide plate in first hammer mode.

FIG. **13** is a view showing movement of the operation mode switching dial and the slide plate in hammer drill mode.

FIG. **14** is a circuit diagram of a control circuit **170** in this embodiment.

DETAILED DESCRIPTION OF THE INVENTION

Each of the additional features and method steps disclosed above and below may be utilized separately or in conjunction with other features and method steps to provide and manufacture improved power tools, method for using such power tools and devices utilized therein. Representative examples of the present invention, which examples utilized many of these additional features and method steps in conjunction, will now be described in detail with reference to the drawings. This detailed description is merely intended to teach a person skilled in the art further details for practicing preferred aspects of the present teachings and is not intended to limit the scope of the invention. Only the claims define the scope of the claimed invention. Therefore, combinations of features and steps disclosed within the following detailed description may not be necessary to practice the invention in the broadest sense, and are instead taught merely to particularly describe some representative examples of the invention, which detailed description will now be given with reference to the accompanying drawings.

An embodiment of the invention is now described with reference to FIGS. **1** to **14**. FIG. **1** shows an entire representative electric hammer drill **101** as one example of a power tool according to the invention. As shown in FIG. **1**, the representative hammer drill **101** includes a body **103** that forms an outer shell of the hammer drill **101**, an elongate hammer bit **119** detachably coupled to a tool holder (not shown) in a tip end region (on the left side as viewed in FIG. **1**) of the body **103** in the longitudinal direction, and a handgrip **109** that is connected to the other end (right end as viewed in FIG. **1**) of the body **103** in the longitudinal direction and designed to be held by a user. The body **103**, the hammer bit **119** and the handgrip **109** are features that correspond to the "tool body", the "tool bit" and the "handle (to be held by a user)", respectively, according to the invention. The hammer bit **119** is mounted to the tool holder which is a feature that corresponds to a "tool bit mounting part" in this invention such that it is allowed to reciprocate with respect to the tool holder in its axial direction (the longitudinal direction of the body **103**) and prevented from rotating with respect to the tool holder in its circumferential direction. For the sake of convenience of explanation, the side of a hammer bit **119** is taken as the front and the side of the handgrip **109** as the rear.

The body **103** includes a motor housing **105** that houses a driving motor **111**, and a gear housing **107** that houses a motion converting mechanism **113**, a striking mechanism **115** and a power transmitting mechanism **117**. The driving motor **111** is a feature that corresponds to the "motor" according to this invention. The driving motor **111** is disposed such that its rotating shaft extends in a direction (vertical direction as viewed in FIG. **1**) substantially perpendicular to the longitudinal direction of the body **103** (the axial direction of the hammer bit). The rotating output of the driving motor **111** is appropriately converted to linear motion by the motion converting mechanism **113** and then transmitted to the striking mechanism **115**. As a result, an impact force is generated in the axial direction of the hammer bit **119** via the striking mechanism **115**. Further, the speed of the rotating output of the driving motor **111** is appropriately reduced by the power transmitting mechanism **117** and then transmitted to the hammer bit **119**. As a result, the hammer bit **119** is caused to rotate in the circumferential direction.

The handgrip **109** is designed as a handle to be held by a user and disposed on the side of the body **103** opposite from the tool holder in the axial direction of the hammer bit **119**. The handgrip **109** is generally U-shaped in side view and extends in a vertical direction transverse to the axial direction of the hammer bit. One end (lower end) of the handgrip **109** in the vertical direction is connected to a lower portion of the rear end of the motor housing **105**, and the other end (upper end) is connected to an upper portion of the rear end of a rear cover **108** which covers a rear region of the motor housing **105** and the gear housing **107**, via a vibration-absorbing coil spring **161**. The coil spring **161** is a feature that corresponds to the "vibration-proofing cushioning material" according to this invention. In this manner, the handgrip **109** is constructed to have a vibration-proof structure which can prevent or reduce transmission of vibration from the body **103** to the handgrip **109**.

The motion converting mechanism **113** which serves to convert rotation of the driving motor **111** to linear motion and transmit it to the striking mechanism **115**, is formed by a crank mechanism including a crank shaft **121** that is driven by the driving motor **111**, a crank arm **12**, and a piston **125**. The piston **125** is a driving element that drives the striking mechanism **115** and can slide in the axial direction of the hammer bit within a cylinder **127**.

The striking mechanism **115** mainly includes a striking element in the form of a striker **129** and an intermediate element in the form of an impact bolt **131**. The striker **129** is slidably disposed within the bore of the cylinder **127** and linearly driven via the action of an air spring which is caused within the cylinder bore by sliding movement of the piston **125**, and the impact bolt **131** is slidably disposed within the tool holder and transmits the kinetic energy of the striker **129** to the hammer bit **119**.

The hammer bit **119** held by the tool holder is rotationally driven together with the tool holder via the power transmitting mechanism **117** by the driving motor **111**. As shown in FIG. **1**, the power transmitting mechanism **117** includes an intermediate gear **133** that is rotationally driven by the driving motor **111**, an intermediate shaft **135**, a first bevel gear **137** that rotates together with the intermediate shaft **135**, and a second bevel gear **139** that engages with the first bevel gear **137** and rotates on a longitudinal axis of the body **103**. The power transmitting mechanism **117** transmits rotation of the driving motor **111** to the tool holder and further to hammer bit **119** held by the tool holder.

A clutch, which is not shown, is disposed between the intermediate gear **133** and the intermediate shaft **135** and serves to transmit the rotating output of the driving motor **111** to the hammer bit **119** or to interrupt such transmission. The clutch is mounted such that it is fixed in the circumferential direction and slidable in the axial direction with respect to the intermediate shaft **135**. The clutch can be switched by sliding along the intermediate shaft **135** between a power transmission state in which the clutch is engaged with clutch teeth of the intermediate gear **133** and a power transmission interrupted state in which such engagement is released.

The clutch can be switched by manually operating an operation mode switching dial **151** for selecting (switching) an operation mode (which is also referred to as a "drive mode") of the hammer bit **119**. The operation mode switching dial **151** is a feature that corresponds to the "operation mode switching member" according to this invention. The operation mode switching dial **151** is disposed externally on the upper surface of the body **103** (above the crank mechanism) such that it can be turned in a horizontal plane around a vertical axis of rotation **151***a* extending transversely to an axis of the hammer bit **119**. When the operation mode switching dial **151** is turned, the clutch of the power transmitting mechanism **117** is switched either to the power transmission state or to the power transmission interrupted state via a clutch switching mechanism **118**. The clutch switching mechanism **118** is disposed within the gear housing **107** (as partly shown in FIG. **1**) and serves to convert rotation of the operation mode switching dial **151** to linear motion and cause the clutch to move along the intermediate shaft **135**. The clutch switching mechanism **118** is not directly related to this invention and therefore it is not described in further detail.

The operation mode is selected by turning the operation mode switching dial **151** around the rotation axis **151***a*. In this embodiment, the operation mode switching dial **151** can switch among first hammer mode, second hammer mode, hammer drill mode and neutral mode. The first hammer mode, second hammer mode, hammer drill mode and neutral mode are appropriately marked on an outer surface of the body **103** around the operation mode switching dial **151**.

When the first or second mode is selected by turning the operation mode switching dial **151**, the clutch of the power transmitting mechanism **117** is placed in the power transmission interrupted state by the clutch switching mechanism **118**. In this state, when the driving motor **111** is driven, only the motion converting mechanism **113** is driven. The rotating output of the driving motor **111** is transmitted to the motion converting mechanism **113**, and the piston **125** of the motion converting mechanism **113** is caused to reciprocate within the bore of the cylinder **127**. When the piston **125** is caused to reciprocate, the motion of the piston **125** is transmitted to the hammer bit **119** via the striker **129** and the impact bolt **131** and the hammer bit **119** performs a striking movement. Thus, in the first or second mode in which the clutch is placed in the power transmission interrupted state, the hammer bit **119** performs hammering operation on a workpiece such as a concrete only by a striking movement (hammering movement).

When the hammer drill mode is selected, the clutch of the power transmitting mechanism **117** is placed in the power transmission state by the clutch switching mechanism **118**. In this state, when the driving motor **111** is driven, not only the motion converting mechanism **113** but the power transmitting mechanism **117** is driven. The rotating output of the driving motor **111** is transmitted to the tool holder and the hammer bit **119** held by the tool holder via the intermediate gear **133**, the clutch, the intermediate shaft **135** and the first and second bevel gears **137**, **139**. Thus, in the hammer drill mode in which the clutch is placed in the power transmission state, the hammer bit **119** performs hammer drill operation on a by striking movement in its axial direction and rotation in its circumferential direction (drilling movement).

An operating member (switching structure) for starting and stopping the driving motor **111** (the hammer bit **119**) is now described with reference to FIGS. **6** to **9**. A first operating member **143** for turning on and off a first switch **141** (for placing it in an on state or an off state) is provided on the handgrip **109** side, and a second operating member **145** for turning on and off a second switch **146** (for placing it in an on state or an off state) is provided on the body **103** side. The first switch **141** and the second switch **146** are features that correspond to the "first switch" and the "second switch", respectively, according to this invention. The first operating member **143** and the second operating member **145** are features that correspond to the "first operating member" and the "second operating member", respectively, according to this invention. The first operating member **143** is a trigger-type switch which can be operated by depressing, and the second operating member **145** is a lever-type switch which can be operated by pushing. The first operating member **143** and the second operating member **145** are opposed to each other in the fore-and-aft direction (the axial direction of the hammer bit **119**) and both can be operated by fingers of the user's hand holding the handgrip **109**. Therefore, the operating section can be operated by one hand, so that its operability can be improved.

The first operating member **143** is disposed in a handgrip internal space **109***b* of the hollow handgrip **109**. The first operating member **143** extends in a longitudinal direction of the handgrip **109** (vertical direction transverse to the axial direction of the hammer bit **119**) and is mounted to the handgrip **109** at its lower end in the extending direction by a mounting shaft **142** such that it can pivot in the fore-and-aft direction (the axial direction of the hammer bit **119**). The first operating member **143** can be pivotally operated between an off position in which the first switch **141** is turned off (or "placed in the off state") and an on position in which the first switch **141** is turned on (or "placed in the on state") by depressing its upper portion by user's finger.

The first operating member **143** is normally biased away from the on position toward the off position by a spring (not shown) which is incorporated in the first switch **141** in order to hold the first switch **141** in the off state by the biasing force. The spring here is a feature that corresponds to the "biasing means" according to this invention. Therefore, in the state in which the first operating member **143** is not depressed, the upper portion of the first operating member **143** is held in the off position in which it protrudes forward through a front opening of the handgrip **109** (see FIG. **6**). In the on position in which it is depressed by finger or pressed in by a slide plate **153** which is described below, the first operating member **143** is housed in the internal space **109***b* of the handgrip **109** such that its front surface is substantially flush with the outer surface of the front of the grip (see FIG. **7**). The first switch **141** is designed as an automatic return type on-off switch which is biased so as to be held in the off state by the incorporated spring. The handgrip internal space **109***b* is a feature that corresponds to the "first housing space" according to this invention.

The second operating member **145** is disposed in a rear internal space **103***a* within the body **103**. The rear internal space **103***a* here is a feature that corresponds to the "second housing space" according to this invention. The rear internal space **103***a* is provided as a space surrounded by the gear housing **107** and the rear cover **108** which covers a rear surface region of the gear housing **107**. The second operating member **145** is a rectangular plate-like member (see FIG. **5**) which is opposed to the first operating member **143** and extends in the vertical direction transverse to the axial direction of the hammer bit **119**. The second operating member **145** has a shaft **145***c* on its lower end in its extending direction and can pivot in the fore-and-aft direction (the axial direction of the hammer bit **119**) with the shaft **145***c* supported by a receiving member **149**.

The rear region of the body **103** in which the second operating member **145** is disposed is a region remote from the hammer bit **119** and hidden when viewed from the hammer bit **119** side. Therefore, the second operating member **145** disposed in this rear region is not easily affected by dust of the which is generated during hammering or hammer drill operation, so that the dust resistance is enhanced.

The second operating member **145** is pivotally operated between an off position in which it is not operated by user's finger and an on position in which it is operated by user's finger to apply a pressing force to the second switch **146**. The second operating member **145** is normally biased away from the on position toward the off position by a spring **147**. Further, a push button **145***a* to be pushed forward by the user's finger is formed in about the middle of the rear surface of the second operating member **145** in its extending direction. Therefore, as long as the push button **145***a* of the second operating member **145** is not pressed by user's finger, the second operating member **145** is held in the off position and the push button **145***a* protrudes rearward through an opening **108***a* of the rear cover **108**. This state is shown in FIGS. **6** and

7. Further, once the second switch **146** is pressed by the second operating member **145** and turned on, the second switch **146** is held in the on state until it is pressed again.

The receiving member **149** is provided as a member for supporting the second switch **146** and the second operating member **145** and fastened to the gear housing **107** by screws **148** (see FIG. **5**). The receiving member **149** has a plurality of claws **149***a* that hold the second switch **146** therebetween in the vertical direction. Further, the receiving member **149** has a generally U-shaped receiving portion **149***b* that supports the second operating member **145**. Within the receiving portion **149***b*, a lower region of the second operating member **145** is housed and the shaft **145***c* is rotatably supported. Therefore, the lower region of the second operating member **145** and the generally U-shaped receiving portion **149***b* overlap each other. Due to the labyrinth effect of such a structure, the effect of preventing entry of dust into the pivot shaft receiving area of the second operating member **145** can be obtained, so that the dust resistance can be further enhanced, coupled with the above-described configuration effect of dust proofing.

Further, in the second operating member **145**, at least the push button **145***a* is formed of a translucent material, and a light **167** such as a light emitting diode (LED) is disposed inside the push button **145***a*. The light **167** is turned on or off according to the position of the first operating member **143** or the second operating member **145** or to the selected operation mode, which will be described below.

Next, a slide plate **153** is explained which is provided as a switch actuating means which forcefully and selectively locks the first operating member **143** or the second operating member **145** in the on position, or releases such lock to allow it to be operated by user's finger, according to the mode selection of the operation mode switching dial **151**. This slide plate **153** is shown in FIGS. **2** and **6** to **13**. The slide plate **153** is linearly moved in the axial direction of the hammer bit **119** via the eccentric shaft **152** according to the turning movement of the operation mode switching dial **151** which is operated to switch the operation mode.

As shown in FIG. **2**, the slide plate **153** is an elongate member extending in the axial direction of the hammer bit **119**. The slide plate **153** extends to the handgrip **109** side through an upper connecting region **109***a* of the handgrip **109** for connection with the body **103**. When second hammer mode T**2** is selected with the operation mode switching dial **151**, the slide plate **153** is moved toward the handgrip **109** to a rear end position by an eccentric shaft **152**. Thus the slide plate **153** releases the lock of the second operating member **145**, while pushing the first operating member **143** rearward to the on position and locking it in the on position. This state is shown in FIGS. **2**, **7** and **11**. When the operation mode switching dial **151** is switched from second hammer mode T**2** to first hammer mode T**1** or hammer drill mode HD, the slide plate **153** is moved forward away from the handgrip **109**, so that it releases the lock of the first operating member **143**, while pushing the second operating member **145** forward to the on position and locking it in the on position. This state is shown in FIGS. **8**, **9** **12** and **13**. The structure of connecting the slide plate **153** and the eccentric shaft **152** will be described below in detail.

As shown in FIG. **6**, the first operating member **143** includes an operating member body **143***a* which has a generally U-shaped cross section (see FIG. **4**) and is designed to be depressed by user's finger, a lever **143***b* which has a generally U-shaped cross section (see FIG. **4**) and is mounted at its lower end to the operating member body **143***a* such that it can rotate on a fulcrum or pivot (mounting shaft) **144** in the direction of travel of the slide plate **153** (in the direction of pivotal movement of the operating member body **143***a*), and a vibration-absorbing torsion spring **143***c* which elastically connects the lever **143***b* to the operating member body **143***a*.

The lever **143***b* is mounted to an upper end region of the operating member body **143***a* and extends upward in such a manner as to protrude from an upper end surface of the operating member body **143***a*. An upper end portion **143***d* of the lever **143***b* faces a rear end projection **153***a* of the slide plate **153**. One end of the torsion spring **143***c* is engaged with the lever **143***b* and the other end is engaged with the operating member body **143***a*, so that the torsion spring **143***c* exerts a biasing force to rotate the lever **143***b* forward. An initial load (mounting load) of the torsion spring **143***c* which is applied to the lever **143***b* upon assembly is larger than a load of fully depressing the operating member body **143***a* by user's finger (a load which is applied to the spring incorporated in the first switch **141** upon completion of the depressing operation to the on position). Therefore, when the slide plate **153** moves rearward and pushes the upper end portion **143***d* of the lever **143***b* with the rear end projection **153***a*, the lever **143***b* and the operating member body **143***a* are rotated rearward together in one piece. Specifically, the operation of the first operating member **143** to the on position by the slide plate **153** is performed with the lever **143***b* and the operating member body **143***a* held in one piece, so that such operation can be reliably preformed. Further, the maximum position limit of forward rotation of the lever **143***b* is defined by contact of the front surface of the lever **143***b* with the operating member body **143***a*.

The above-described torsion spring **143***c* is provided as an elastic member that absorbs vibration which is caused in the body **103** mainly in the fore-and-aft direction (the axial direction of the hammer bit **119**) and prevents or reduces transmission of vibration from the slide plate **153** to the handgrip **109** via the first operating member **143** when a hammering operation is performed in the state in which the first operating member **143** is forcefully locked in the on position by the slide plate **153** (in second hammer mode T**2**).

The second operating member **145** extends upward within the rear internal space **103***a*, and an upper end **145***b* of the second operating member **145** is movably inserted into a slot **153***b* (opening) which is formed in the slide plate **153** and extends in a longitudinal direction of the slide plate **153**. When the slide plate **153** is moved forward, the second operating member **145** is pushed forward to the on position by a linkage **155** which is elastically connected to the slide plate **153** via a coil spring **154** and locked in the on position.

As shown in FIG. **2**, an opening **153***c* having a larger width than the slot **153***b* is formed in the slide plate **153** and extends contiguously rearward from the slot **153***b*, and the linkage **155** and the coil spring **154** are disposed within the opening **153***c*. The linkage **155** can move in the fore-and-aft direction with respect to the slide plate **153** and is biased forward by the coil spring **154** and held in a position of engagement with a stepped portion **153***f* which is formed in the boundary between the slot **153***b* and the opening **153***c*. The biasing force of the coil spring **154** is larger than the biasing force of the spring **147** which biases the second operating member **145** toward the off position. Therefore, when the slide plate **153** is moved forward, the linkage **155** moves together with the slide plate **153**, and on its way, it engages with the upper end **145***b* of the second operating member **145**. Thus, the linkage **155** moves the second operating member **145** to the on position and locks it in the on position. Specifically, in the state in which the second operating member **145** is forcefully locked in the on position by the slide plate **153**, the second operating member **145** is elastically connected to the slide plate **153** via the coil spring **147**. When the slide plate **153** is further moved forward in the state in which the second operating member **145** is forcefully locked in the on position, the linkage **155** moves with respect to the slide plate **153** while compressing the coil spring **154**. Thus, the difference between the amount of travel of the second operating member **145** and the amount of travel of the slide plate **153** which is caused after engagement between the linkage **155** and the second operating member **145** can be accommodated.

Further, the coil spring **154** disposed within the slot **153***b* is loosely fitted onto a columnar guide **153***d* of the slide plate **153** and a columnar guide **155***a* of the linkage **155** which are opposed to each other, so that a stable supporting structure for the coil spring **154** can be obtained.

Next, a structure of connecting the eccentric shaft **152** of the operation mode switching dial **151** and the slide plate **153** is explained mainly with reference to FIG. **2**. A connecting part **157** is formed on a front end of the slide plate **153** and has an engagement slot **159** extending in a horizontal direction (lateral direction) transverse to the direction of travel (the longitudinal direction) of the slide plate **153**. The eccentric shaft **152** is loosely engaged in the engagement slot **159**. The eccentric shaft **152** is disposed in a position displaced a predetermined distance from the rotation axis **151***a* of the operation mode switching dial **151**. Therefore, when the operation mode switching dial **151** is turned around the rotation axis **151***a*, the eccentric shaft **152** moves the slide plate **153** in the fore-and-aft direction by the component of motion of the eccentric shaft **152** in the fore-and-aft direction (the axial direction of the hammer bit **119**) while moving within the engagement slot **159** in the extending direction of the engagement slot **159** (the lateral direction). Specifically, the eccentric shaft **152** moves the slide plate **153** rearward by pushing a rear engagement surface **159***a* of the engagement slot **159**, and it moves the slide plate **153** forward by pushing a front engagement surface **159***b* of the engagement slot **159**. Further, when the eccentric shaft **152** is in its front end position or rear end position, the eccentric shaft **152** is centrally located within the engagement slot **159** in its extending direction.

In this embodiment, dial settings for the hammer drill mode HD, first hammer mode T**1** and second hammer mode T**2** are made and marked at (different) predetermined angular intervals around the rotation axis **151***a* of the operation mode switching dial **151**, and neutral mode N is set and marked between the hammer drill mode HD and the first hammer mode T**1** and between the hammer drill mode HD and the second hammer mode T**2**.

When the eccentric shaft **152** is caused to revolve rearward around the rotation axis **151***a* and the second hammer mode T**2** is selected, the eccentric shaft **152** is centrally located within the engagement slot **159** (the eccentric shaft **152** is located in its rear end position). At this time, as described above, the slide plate **153** is moved to its rear end position, and the first operating member **143** is pushed rearward by the slide plate **153** and locked in the on position (see FIG. **7**). When the eccentric shaft **152** is caused to revolve forward in a clockwise direction around the rotation axis **151***a* from the position of the second hammer mode T**2** and the first hammer mode T**1** is selected, the eccentric shaft **152** is located toward one end (lower end as shown in FIG. **12**) within the engagement slot **159** in the extending direction of the engagement slot **159**. When the eccentric shaft **152** is caused to revolve forward in a counterclockwise direction around the rotation axis **151***a* from the position of the second hammer mode T**2** and the hammer drill mode HD is selected, the eccentric shaft **152** is located toward the other end (upper end as shown in FIG. **13**). Further, when the first hammer mode T**1** or the hammer drill mode HD is selected, the slide plate **153** is moved forward and the second operating member **145** is pushed forward by the slide plate **153** and locked in the on position (see FIGS. **8** and **9**).

When the neutral mode N between the second hammer mode T**2** and the hammer drill mode HD is selected, as shown in FIGS. **6** and **10**, the slide plate **153** is located at about the midpoint position in the direction of travel. At this time, the rear end projection **153***a* of the slide plate **153** is disengaged from the lever **143***b* of the first operating member **143**, and the linkage **155** is disengaged from the upper end **145***b* of the second operating member **145**. Specifically, in the neutral mode N between the second hammer mode T**2** and the hammer drill mode HD, the first operating member **143** and the second operating member **145** can be placed in the off positions. In the neutral mode N, a process of switching between the hammer drill mode HD in which the tool bit is caused to rotate and the second hammer mode T**2** in which the tool bit is not caused to rotate is a switching process in which both of the first and second switches are placed in the off state. Therefore, this feature corresponds to the feature that "the operation modes include a mode in which the tool bit is caused to rotate and a mode in which the tool bit is not caused to rotate, and a process of switching between these modes includes a switching process in which both of the first and second switches are placed in the off state" according to this invention.

In this embodiment, the engagement slot **159** of the slide plate **153** has an arcuate shape curved forward toward the hammer bit **119** (arched toward the handgrip **109**). Therefore, when the eccentric shaft **152** is caused to revolve, the amount of rearward travel of the slide plate **153** which corresponds to the angle of rotation of the operation mode switching dial **151** differs from the amount of travel of the component of motion of the eccentric shaft **152** in the fore-and-aft direction. Specifically, when the eccentric shaft **152** is caused to revolve from the front end position to the rear end position while pushing the convex arcuate surface or the rear engagement surface **159***a* of the engagement slot **159**, the amount of rearward travel of the slide plate **153** is smaller than the amount of travel of the component of rearward motion of the eccentric shaft **152** in a forward region in which the eccentric shaft **152** moves from higher to lower areas of the convex arcuate surface (in a region in which it moves toward the position of the first hammer mode T**1** and in a region in which it moves toward the position of the neutral mode N between the second hammer mode T**2** and the hammer drill mode HD), while it is larger in a rearward region in which the eccentric shaft **152** moves from the lower to higher areas, i.e., in a region in which it passes the position of the first hammer mode T**1** or the neutral mode N and moves toward the position of the second hammer mode T**2**, wherein the border between the forward and rearward regions is defined by a lateral axis intersecting with the rotation axis **151***a*. Thus, in this embodiment, when the second hammer mode T**2** is selected, the amount of travel of the slide plate **153** is made larger in the rearward region. With such a construction, the amount of travel of the slide plate **153** which is required to move the first operating member **143** to the on position can be easily ensured.

Further, when the eccentric shaft **152** moves the slide plate **153** forward by pushing the concave arcuate surface or the front engagement surface **159***b* of the engagement slot **159**, the amount of travel of the slide plate **153** is larger than the amount of travel of the component of forward motion of the eccentric shaft **152** in a rearward region in which the eccentric shaft **152** moves from lower to higher areas of the concave arcuate surface, while it is smaller in a forward region in which it moves from higher to lower areas of the concave arcuate surface. In other words, such is the reverse of the above-described phenomenon in rearward movement.

Further, in this embodiment, an escape recess **159***c* is formed in a central region of the front engagement surface **159***b* of the engagement slot **159** in the extending direction of its arc and recessed forward. The escape recess **159***c* is formed by a circular arc surface having a radius corresponding to the distance of displacement of the eccentric shaft **152** (the distance from the rotation axis **151***a* to the center of the eccentric shaft **152**). Specifically, when the eccentric shaft **152** moves the slide plate **153** forward by pushing the front engagement surface **159***b* of the engagement slot **159**, the eccentric shaft **152** is opposed to the escape recess **159***c* in the forward region or particularly in the vicinity of the end of forward movement. As a result, thereafter, further forward movement of the slide plate **153** is prevented. When the hammer drill mode HD or the first hammer mode T**1** is selected, the slide plate **153** moves the second operating member **145** to the on position via the linkage **155**. When the slide plate **153** is moved further forward from this position, as shown in FIG. **13**, the linkage **155** pushing the second operating member **145** moves with respect to the slide plate **153** while compressively deforming the coil spring **154**. Thus, the construction having the escape recess **159***c* in the front engagement surface **159***b* is effective in reducing the amount of relative movement of the linkage **155** with respect to the slide plate **153** in the vicinity of the forward end position of the slide plate **153** (in a region of switching between the hammer drill mode HD and the other neutral mode N) when the slide plate **153** is moved forward, so that undesired compressive deformation of the coil spring **154** can be reduced.

Further, a horn-like projection **143***e* is formed on the upper end of the operating member body **143***a* of the first operating member **143**. When the operation mode switching dial **151** is switched to the second hammer mode T**2**, the slide plate **153** is moved rearward and the rear projection **153***a* of the slide plate **153** pushes the upper end portion **143***d* of the lever **143***b* so that the first operating member **143** is rotated to the on position. At this time, the projection **143***e* enters the opening **153***c* of the side plate **153**. This state is shown in FIGS. **7** and **11**. When the operation mode switching dial **151** is switched from the second hammer mode T**2** to the hammer drill mode HD or the first hammer mode T**1** and the slide plate **153** is moved forward, the projection **143***e* is engaged with a rear edge **153***e* of the opening **153***c* so that the first operating member **143** is forcefully returned to the off position.

A pair of right and left vibration-absorbing coil springs **161** are disposed in the upper connecting region **109***a* of the handgrip **109** for connection with the body **103** and elastically connect the handgrip **109** and the body **103**. As shown in FIG. **2**, the coil springs **161** are disposed in parallel on the opposite sides of the axis of the hammer bit **119** such that they extend and contract in the axial direction of the hammer bit **119**. The slide plate **153** is disposed between the coil springs **161** on the axis of the hammer bit **119**. The slide plate **153** and the coil springs **161** are covered by a rubber bellows **165**.

Operation and usage of the electric hammer drill **101** constructed as described above are now described. FIGS. **6** and **10** show the state in which the neutral mode N is selected by turning the operation mode switching dial **151**. In this state, the eccentric shaft **152** is located toward one end of the engagement slot **159**, and the slide plate **153** is located at about the midpoint position in the direction of travel. In this state, as shown in FIG. **6**, the rear end projection **153***a* of the slide plate **153** is disengaged from the lever **143***b* of the first operating member **143**, and the linkage **155** of the slide plate **153** is disengaged from the upper end **145***b* of the second operating member **145**. Therefore, both the first operating member **143** and the second operating member **145** are in their off positions, and both the first switch **141** and the second switch **146** are off. Thus, the driving motor **111** is held shut down.

Next, FIGS. **7** and **11** show the state in which the operation mode switching dial **151** is switched from the neutral mode N to the second hammer mode T**2**. In this state, rotation of the operation mode switching dial **151** is transmitted as linear motion to the clutch of the power transmitting mechanism **117** via the clutch switching mechanism **118**, and the clutch is switched to the power transmission interrupted state. At the same time, the eccentric shaft **152** is caused to revolve to the rear end position and moves the slide plate **153** rearward. Then, as shown in FIG. **7**, the rear end projection **153***a* of the slide plate **153** pushes the upper end portion **143***d* of the lever **143***b* of the first operating member **143** rearward. As a result, the first operating member **143** pivots around the mounting shaft **142** to the on position with the lever **143***b* and the operating member body **143***a* held in an integrally connected state by the biasing force of the torsion spring **143***e*, and thus turns on the first switch **141**. Specifically, the first operating member **143** is forcefully locked in the on position by the slide plate **153**.

In this state, when the push button **145***a* of the second operating member **145** is pushed forward by user's finger, the second operating member **145** pivots around the shaft **145***c* to the on position and turns on the second switch **146**. Thus, the driving motor **111** is driven, and as described above, this energized state is maintained even if the second operating member **145** is released. Therefore, without need of continuing pressing the second operating member **145** by finger, the user can continuously drive the driving motor **111** to cause the hammer bit **119** to perform linear striking movement via the motion converting mechanism **113** and the striking mechanism **115** and thus can continuously perform a hammering operation on a workpiece. The second hammer mode T**2** is a feature that corresponds to the "second hammer mode" according to this invention. In order to stop the hammering operation, the second operating member **145** is pressed again. Then the second switch **146** is turned off and the driving motor **111** is stopped.

In this case, in operation using the electric hammer drill **101**, the user holds the handgrip **109** and presses the hammer bit **119** against the workpiece while applying a pressing force to the body **103** in the axial direction of the hammer bit **119**. Therefore, when the hammer bit **119** is pressed against the workpiece, the handgrip **109** pivots forward toward the body **103** around a pivot **163**. Then the lever **143***b* of the first operating member **143** is pushed further rearward by the slide plate **153** and pivots around the fulcrum **144** against the torsion spring **143***c* so that the front surface of the lever **143***b* is disengaged from the rear surface of the operating member body **143***a*. This state is shown in FIG. **3**. Thus, the first operating member **143** is elastically connected to the slide plate **153** in the state in which it is forcefully locked in the on position by the slide plate **153**. Therefore, even if the slide plate **153** vibrates together with the body **103** due to vibration caused in the body **103** during hammering operation, transmission of vibration from the slide plate **153** to the first operating member **143** can be prevented or reduced by the torsion spring **143***c*.

FIGS. **8** and **12** show the state in which the first hammer mode T**1** is selected with the operation mode switching dial **151**. In this state, the clutch of the power transmitting mechanism **117** is in the power transmission interrupted state. At the same time, the eccentric shaft **152** is located at about the midpoint position in its travel in the fore-and-aft direction. Thus the slide plate **153** is moved forward when viewed from its rear end position in the second hammer mode T**2**. Therefore, as shown in FIG. **8**, the linkage **155** of the slide plate **153** is engaged with the upper end **145***b* of the second operating member **145** and pushes it forward. Then the second operating member **145** pivots forward to the on position around the shaft **145***c* and turns on the second switch **146**.

By the forward movement of the slide plate **153**, the rear end projection **153***a* of the slide plate **153** is disengaged from the lever **143***b* of the first operating member **143**. Thus, the lock of the first operating member **143** is released and the first operating member **143** is allowed to be operated by user's finger. Therefore, the driving motor **111** is driven when the operating member body **143***a* of the first operating member **143** is depressed by user's finger to turn on the first switch **141**, while the driving motor **111** is stopped when the depressing of the first switch **141** is released. In the first hammer mode T**1**, the clutch of the power transmitting mechanism **117** is in the power transmission interrupted state, so that the hammer bit **119** performs only linear striking movement when the driving motor **111** is driven. Thus, in the first hammer mode T**1**, the user can arbitrarily start and stop the driving motor **111** by operating the first operating member **143** by finger in order to intermittently (sporadically) perform a hammering operation on a workpiece by the hammer bit **119**. The first hammer mode T**1** is a feature that corresponds to the "first hammer mode" according to this invention.

FIGS. **9** and **13** show the state in which the hammer drill mode HD is selected with the operation mode switching dial **151**. In this state, the clutch of the power transmitting mechanism **117** is placed in the power transmission state. At the same time, the eccentric shaft **152** is revolved further forward than in the first hammer mode T**1**. Thus, as shown in FIG. **13**, the slide plate **153** is moved forward by the eccentric shaft **152**, but the linkage **155** is prevented from moving further forward when the second operating member **145** reaches its on position. Therefore, the linkage **155** which is connected to the slide plate **153** via the coil spring **154** moves with respect to the slide plate **153** while compressively deforming the coil spring **154**. Thus, the difference between the amount of travel of the second operating member **145** and the amount of travel of the slide plate **153** is accommodated. When the second operating member **145** is pivoted to the on position, the second switch **146** is turned on.

Further, by the forward movement of the slide plate **153**, like in the first hammer mode T**1**, the rear end projection **153***a* of the slide plate **153** is disengaged from the lever **143***b* of the first operating member **143**, so that the first operating member **143** is allowed to be arbitrarily operated by user's finger. Further, in the hammer drill mode HD, the clutch of the power transmitting mechanism **117** is placed in the power transmission state via the clutch switching mechanism **118**. Therefore, in the hammer drill mode HD, the user can arbitrarily start and stop the driving motor **111** by operating the first operating member **143** by finger. Thus the user can intermittently (sporadically) perform a hammer drill operation on a workpiece by linear striking movement of the hammer bit **119** and its rotation in its circumferential direction. The hammer drill mode HD is a feature that corresponds to the "hammer drill mode" according to this invention.

Now, a control circuit **170** of the electric hammer drill **101** according to this embodiment is explained with reference to FIG. **14**. FIG. **14** is a circuit diagram of the control circuit **170** in this embodiment. The control circuit **170** is formed by a controller **171** as well as the above-described driving motor **111** and first and second switches **141**, **146**.

The controller **171** is a control device for at least controlling the driving motor **111** and includes a circuit power supply section **172**, a switch detecting circuit **173**, a computing/driving section **174**, a motor control circuit power supply section **175**, a motor control section **176**, and a drive circuit **177**. The controller **171** is a feature that corresponds to the "control device" according to this invention.

The circuit power supply section **172** is designed as a section for supplying external power to the switch detecting circuit **173** and the computing/driving section **174**. The switch detecting circuit **173** is designed to detect whether each of the first switch **141** and the second switch **146** is in the on position or in the off position. Specifically, the switch detecting circuit **173** serves to detect the on/off state of the first and second switches **141**, **146**. The switch detecting circuit **173** here is a feature that corresponds to the "switch detecting section" according to this invention.

The computing/driving section **174** includes a computing part for computing based on information detected in the switch detecting circuit **173**, and a driving part for driving a motor control circuit according to the computation. Particularly, the computing part of the computing/driving section **174** executes at least processing for determining the mode of operation of the hammer bit **119** according to the on/off state of the first and second switches **141**, **146** when the power is on. The state in which the "power is on" herein widely includes the on state of the power, and such a state is typically created immediately after the power is turned on. Specifically, the computing/driving section **174** serves to determine the operation mode based on the results of detection of the switch detecting circuit **173**. The computing/driving section **174** here is a feature that corresponds to the "operation mode determining section" according to this invention.

The motor control circuit power supply section **175** is designed as a section for supplying external power to the motor control circuit. The motor control section **176** and the drive circuit **177** form a mechanism for controlling drive of the driving motor **111**. The motor control section **176** and the drive circuit **177** form the "drive control section" according to this invention.

In the controller **171** having the above-described construction, the computing/driving section **174** determines whether the hammer drill **101** is placed in first operation mode (the above-described second hammer mode T**2**) or in second operation mode (the above-described first hammer mode T**1** or hammer drill mode HD), based on the results of detection of the switch detecting circuit **173**. With such a construction, it can be readily determined which one of the operation modes is currently selected. Particularly, by provision of the switch detecting circuit **173** for directly detecting the on/off state of the first and second switches **141**, **146**, an additional switch to be provided for this purpose can be rationally dispensed with.

Next, the first to fourth determinations on the hammer drill **101** by the computing/driving section **174** are described.

(First Determination)

If the switch detecting circuit **173** detects that the first switch **141** is in the on position and the second switch **146** is in the off position when the power is turned on, it is determined that the hammer drill **101** is placed in the first operation mode (first determination). In the first operation mode, the first switch **141** is locked in the on position, and on-off operation of the second switch **146** is enabled. Based on the first determination, the controller **171** outputs a drive control signal to the driving motor **111** when the second switch **146** is turned from the off position to the on position after determination of the operation mode. Thus the driving motor **111** is started. Further, in this embodiment, as the second switch **146**, particularly an electronic switch may be used which energizes and de-energizes the driving motor **111** by electric signals generated upon pressing operation of the second operating member **145**. By using such an electronic switch, the energized state of the driving motor **111** can be continued with one click. This electronic switch is designed as a switch which does not have a mechanical contact for passing and interrupting motor current of the driving motor **111**. By provision of such an electronic switch, the second switch **146** can be reduced in size and the second operating member **145** can be pressed with a light touch so that ease of operation is enhanced. In the first operation mode, the driving motor **111** is stopped when the second switch **146** is placed in the off position after the driving motor **111** is started.

(Second Determination)

If the switch detecting circuit **173** detects that the first switch **141** is in the off position and the second switch **146** is in the on position when the power is turned on, it is determined that the hammer drill **101** is placed in the second operation mode (second determination). In the second operation mode, the second switch **146** is locked in the on position, and on-off operation of the first switch **141** is enabled. Based on the second determination, the controller **171** outputs a drive control signal to the driving motor **111** when the first switch **141** is turned from the off position to the on position after determination of the operation mode. Thus the driving motor **111** is started.

(Third Determination)

If the switch detecting circuit **173** detects that both the first switch **141** and the second switch **146** are in the on position when the power is turned on, it is determined that the hammer drill **101** is not in normal conditions (third determination). Specifically, in this timing before starting an operation of the hammer drill, the condition in which both of the first and second switches **141**, **146** are in the on position means that a switch is left on, for example, due to user's misoperation or dust deposition, or the switch is faulty. Therefore, in the case of the third determination, even if both of the first and second switches **141**, **146** are in the on position, the controller **171** disables driving of the driving motor **111**.

At this time, preferably, it is controlled to inform the user of the abnormal condition, for example, by using a warning lamp. Further, it is preferable to indicate by illumination which one of the operation modes is currently selected. In this embodiment, a light **167** is provided as the illumination and designed to indicate an abnormal condition when both of the first and second switches **141**, **146** are in the on position. The light **167** herein is a feature that corresponds to the "indicating section" according to this invention. With such a construction, the user can easily identify the current operation mode indicated by the light **167** based on the on-off state of the second switch **146**. The indication by the light **167** can be realized by flashing or illuminating in a single color or multiple colors. The light **167** may be designed as necessary, for example, to indicate that the second switch **146** is in the off state, or to indicate that the second switch **146** is in the on state, or to indicate that the second switch **146** has been switched between the on state and the off state. Thereafter, when either the first switch **141** or the second switch **146** is placed in the on position, the above-described first or second operation mode is entered.

(Fourth Determination)

If the switch detecting circuit **173** detects that both of the first and second switches **141**, **146** are in the off position when the power is turned on, it is determined that the hammer drill **101** is placed in the neutral mode between the above-described second hammer mode T**2** and hammer drill mode HD (fourth determination). In this neutral mode, driving of the driving motor **111** is disabled. Thereafter, when either the first switch **141** or the second switch **146** is turned from this neutral mode to the on position, the above-described first or second operation mode is entered.

It is essential for the computing/driving section **174** to make a determination based on detection of the switch detecting circuit **173** at least when the power is in the on state. Therefore, the determination may be made when the power is turned on as described above, or it may be made at an appropriate time, for example, after completion of normal operation of the hammer drill.

The electric hammer drill **101** according to this embodiment has the vibration-proof handgrip **109** having the lower end connected to the body **103** such that it can rotate on the pivot **163** in the fore-and-aft direction and having the upper end connected to the body **103** via the vibration-absorbing coil springs **161**. Therefore, during hammering or hammer drill operation, transmission of vibration particularly in the axial direction of the hammer bit **119** from the body **103** to the handgrip **109** can be reduced by the coil springs **161**.

During operation in the second hammer mode T**2**, as described above, the first operating member **143** on the handgrip **109** side is forcefully locked in the on position by the slide plate **153** on the body **103** side. Therefore, if the connection between the body **103** and the handgrip **109** is made by a rigid structure, vibration on the body **103** side will be transmitted from the slide plate **153** to the handgrip **109** via the first operating member **143**.

Therefore, in this embodiment, the first operating member **143** is formed by the operating member body **143***a* and the lever **143***b* which are connected by the torsion spring **143***c*, so that transmission of vibration from the slide plate **153** to the first operating member **143** is absorbed by utilizing elastic deformation of the torsion spring **143***c* (see FIG. **3**). Specifically, according to this embodiment, with such a construction, the vibration-proofing structure of the first operating member **143** is rationally provided on the first operating member **143** side. Thus, the mode selecting function of selecting the operation mode between the second hammer mode T**2** in which the first operating member **143** is forcefully locked in the on position and the first hammer mode T**1** and hammer drill mode HD in which the first operating member **143** can be arbitrarily operated by the user and the function of proofing vibration of the handgrip **109** by connecting the handgrip **109** to the body **103** via the coil springs **161** can be simultaneously realized.

In this case, in this embodiment, the initial load of the torsion spring **143***c* which is applied to the lever **143***b* upon assembly is designed to be larger than a load which is applied to the built-in off-position biasing spring in the first switch **141** when the operating member body **143***a* is placed in the on position to turn on the switch **141**. Therefore, in the second hammer mode T**2**, the first operating member **143** can be reliably locked in the on position, and the effect of reducing vibration transmission by the torsion spring **143***c* can be obtained.

In any operation mode other than the second hammer mode T**2** of continuously performing hammering operation, the forceful lock of the first operating member **143** in the on position by the slide plate **153** is released. Therefore, transmission of vibration from the body **103** to the handgrip **109** can be reduced by the coil springs **161** which connect the handgrip **109** and the body **103**. In other words, from another viewpoint, in the electric hammer drill **101** according to this embodiment, the function of reducing vibration of the handgrip **109** is performed by both the coil springs **161** and the torsion spring **143***c* in the second hammer mode T**2**, while it is performed only by the coil springs **161** in the other operation modes. Specifically, the vibration-proofing spring load of the handgrip **109** in the second hammer mode T**2** is different from that in the other operation modes. Therefore, with such a construction, both the operation mode selecting function and the vibration-proof handgrip **109** can be simultaneously realized.

Further, in this embodiment, in the first hammer mode T**1** or the hammer drill mode HD, the switch-actuating slide plate **153** for pushing the second operating member **145** to the on position is designed to perform such pushing operation via the linkage **155** which is elastically connected to the slide plate **153** via the coil spring **154**. Therefore, the difference between the amount of travel of the second operating member **145** and the amount of travel of the slide plate **153** is accommodated by relative movement of the linkage **155** with respect to the slide plate **153**. Thus, the amount of travel of the second operating member **145** and the amount of travel of the slide plate **153** can be arbitrarily and individually set, so that higher freedom of design is obtained.

Further, the first operating member **143** is housed in the internal space **109***b* (first housing space) of the handgrip **109** when it is pushed by the slide plate **153** to the on position in the second hammer mode T**2**. This construction is a feature that corresponds to the construction in which "the handle has a first housing space in which the first operating member can be housed, and the first operating member is housed in the first housing space in the state in which the first switch is held in the on state by manual operation of the operation mode switching member in the second hammer mode" according to this invention. Further, the second operating member **145** is housed in the rear internal space **103***a* (second housing space) within the body **103** when it is pushed by the slide plate **153** to the on position in the first hammer mode T**1** or the hammer drill mode HD. This construction is a feature that corresponds to the construction in which "the tool body has a second housing space in which the second operating member can be housed and the second operating member is housed in the second housing space in the state in which the second switch is held in the on state by manual operation of the operation mode switching member in the first hammer mode or the hammer drill mode".

Therefore, by visually checking whether the first and second operating members **143**, **145** are housed or not, the user can distinguish whether the currently-selected mode is the second hammer mode T**2** for continuous operation, or the first hammer mode T**1** or hammer drill mode HD for intermittent operation. Further, such a structure of housing the operating sections can prevent the biasing force of the spring (biasing means) from acting upon the user via the first operating member **143** or the second operating member **145**, so that this is effective in smoothly performing the operation.

The first operating member **143** and the second operating member **145** are opposed to each other, so that they can be operated by the one hand holding the handgrip **109**. Further, the rear end region of the body **103** in front of the handgrip **109** is a region remote from the hammer bit **119** and hidden when viewed from the hammer bit **119** side. Therefore, this rear region is not easily affected by dust of the which is generated during hammering or hammer drill operation, so that the dust resistance is enhanced.

Further, in this embodiment, the vibration-absorbing coil springs **161** are disposed on the opposite sides of the axis of the hammer bit **119**, and the slide plate **153** is disposed between the coil springs **161**. In operation using the electric hammer drill **101**, the user holds the handgrip **109** and presses the hammer bit **119** against the workpiece while applying a pressing force to the body **103** in the axial direction of the hammer bit **119**. Therefore, by the above-described arrangement of the coil springs **161** on the opposite sides of the axis of the hammer bit **119**, stability of the handgrip **109** can be achieved during operation with the hammer bit **119** pressed against the workpiece. Further, by the arrangement of the slide plate **153** between the coil springs **161**, a rationally arranged structure can be obtained.

Further, the invention is not limited to the above-described embodiments, but may be appropriately modified or changed. In the above embodiments, the first operating member **143** is connected to the slide plate **153** via an elastic member in the state in which the first operating member **143** is forcefully locked in the on position by the slide plate **153**, and the vibration proofing torsion spring **143***c* is provided on the first operating member **143**. As alternatives to this construction, however, an elastic member such as a spring and rubber may be provided between the slide plate **153** and the first operating member **143**, or an elastic member may be mounted on the slide plate **153**. The structure of mounting an elastic member on the slide plate **153** can be realized, for example, by provision of the construction in which the pushing member of the first operating member **143** is connected to the rear region of the slide plate **153** via the elastic member such that it can move with respect the slide plate **153** in the fore-and-aft direction.

Further, in the present embodiment, in the structure of connecting the eccentric shaft **152** of the operation mode switching dial **151** and the slide plate **153**, the engagement slot **159** is arcuately shaped in order to create a difference between the amount of travel of the slide plate **153** and the amount of travel of the component of motion of the eccentric shaft **152** in the fore-and-aft direction. Alternatively, however, the engagement slot **159** may be shaped to extend linearly in a direction transverse to the fore-and-aft direction. Further, it may be designed such that the selection of the operation mode is made not by turning motion but by linear motion. Further, in this embodiment, the drive modes of the hammer bit **119** is described as including the first hammer mode T**1**, the second hammer mode T**2** and the hammer drill mode HD. In addition to these modes, however, it may be constructed to offer a drill mode in which the hammer bit **119** is caused to perform only rotation.

Further, in the present embodiment, the second operating member **145** is designed to automatically return to the off position when it is released after pushed to the on position. It may however be designed like the second switch **146** to remain in the on position even if it is pushed and then released and to return to the off position when it is pushed again (next time).

Further, in the present embodiment, the electric hammer drill **101** is explained as a representative example of the power tool, but it can also be applied to a hammer in which the hammer bit **119** is caused to perform only a striking movement.

DESCRIPTION OF NUMERALS

101 electric hammer drill (power tool)
103 body (tool body)
103*a* rear internal space
105 motor housing
107 gear housing
108 rear cover

108*a* opening
109 handgrip
109*a* upper connecting region
109*b* handgrip internal space
111 driving motor
113 motion converting mechanism
115 striking mechanism
117 power transmitting mechanism
118 clutch switching mechanism
119 hammer bit (tool bit)
121 crank shaft
123 crank arm
125 piston
127 cylinder
129 striker
131 impact bolt
133 intermediate gear
135 intermediate shaft
137 first bevel gear
139 second bevel gear
141 first switch
142 mounting shaft
143 first operating member
143*a* operating member body
143*b* lever
143*c* torsion spring
143*d* upper end portion
143*e* horn-like projection
144 fulcrum
145 second operating member
145*a* push button
145*b* upper end
145*c* shaft
146 second switch
147 spring
148 screw
149 receiving member
149*a* claw
149*b* U-shaped receiving portion
151 operation mode switching dial (operation mode switching member)
151*a* rotation axis
152 eccentric shaft
153 slide plate
153*a* rear end projection
153*b* slot
153*c* opening
153*d* columnar guide
153*e* rear edge
154 coil spring
155 linkage
155*a* columnar guide
157 connecting part
159 engagement slot
159*a* rear engagement surface
159*b* front engagement surface
159*c* escape recess
161 vibration-absorbing coil spring (vibration-proofing cushioning material)
163 pivot
165 bellows
167 light
170 control circuit
171 controller
172 circuit power supply section
173 switch detecting circuit
174 computing/driving section
175 motor control circuit power supply section
176 motor control section
177 drive circuit

The invention claimed is:

1. A power tool with several operation modes comprising:

a motor,

a tool body that houses the motor,

a tool bit mounting part which is provided on the tool body and to which an elongate tool bit to be driven by the motor is coupled,

a handle held by a user and disposed on the tool body at a side opposite to the tool bit mounting part in an axial direction of the tool bit,

a first switch and a second switch, each of which can be placed in an on state or an off state and

a control device that controls the motor, wherein the control device including:

a switch detecting section that detects the on or off state of each of the first and second switches when power is on,

an operation mode determining section that determines an operation mode based on the on or off state of each of the first and second switches, as detected by the switch detecting section and

a drive control section that, after the operation mode determining section determines the operation mode, outputs a drive control signal to the motor when the switch in the off state is turned on.

2. The power tool as defined in claim **1** comprising an operation mode switching member which can switch between the operation modes by manual operation of a user, wherein the operation modes include a first hammer mode and a second hammer mode for hammering operation in which the tool bit is caused to perform linear striking movement, and in the first hammer mode, by manual operation of the operation mode switching member, the second switch is held in the on state and the first switch is allowed to be turned to the on or off state, while, in the second hammer mode, by manual operation of the operation mode switching member, the first switch is held in the on state and the second switch is allowed to be turned to the on or off state.

3. The power tool as defined in claim **2**, comprising a first operating member which is normally biased toward an off position by a biasing member and which is depressed to an on position against a biasing force of the biasing member in order to turn on the first switch, wherein the handle has a first housing space in which the first operating member can be housed and the first operating member is housed in the first housing space in the state in which the first switch is held in the on state by manual operation of the operation mode switching member in the second hammer mode.

4. The power tool as defined in claim **2**, comprising a second operating member which is repeatedly pressed with user's finger in order to turn the second switch on and off, wherein the tool body has a second housing space in which the second operating member can be housed and the second operating member is housed in the second housing space in the state in which the second switch is held in the on state by manual operation of the operation mode switching member in the first hammer mode or the hammer drill mode.

5. The power tool as defined in claim **4**, wherein the second switch comprises an electronic switch which energizes and de-energizes the motor by electric signals generated upon pressing operation of the second operating member.

6. The power tool as defined in claim **1**, comprising an operation mode switching member which can switch between the operation modes by manual operation of a user, wherein the operation modes include a hammer drill mode for hammer drill operation in which the tool bit is caused to perform linear striking movement and rotation in the circumferential direction of the bit, and in the hammer drill mode, by manual operation of the operation mode switching member, the second switch is held in the on state and the first switch is allowed to be turned to the on or off state.

7. The power tool as defined in claim **1**, wherein the operation modes include a mode in which the tool bit is caused to rotate and a mode in which the tool bit is not caused to rotate, and a process of switching between these modes includes a switching process in which both of the first and second switches are placed in the off state.

8. The power tool as defined in claim **1**, comprising an indicating section that indicates by illumination which one of the operation modes is currently selected.

9. The power tool as defined in claim **8**, wherein the indicating section indicates the current operation mode based on the on-off state of the second switch.

10. The power tool as defined in claim **1**, comprising a vibration-proofing cushioning material which is disposed between the tool body and the handle and connects the tool body and the handle such that the tool body and the handle can move with respect to each other in the axial direction of the tool bit.

11. The power tool as defined in claim **1**, comprising a first operating member which is normally biased toward an off position by a biasing member and which is depressed to an on position against a biasing force of the biasing member in order to turn on the first switch, and a second operating member which is repeatedly pressed with user's finger in order to turn the second switch on and off, wherein the first operating member is disposed on the tool bit mounting part side of the handle and the second operating member is disposed in a region of the tool body which faces the first operating member.

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